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HIGH SCHOOL APPRENTICESHIP PROGRAM FINAL REPORTS

VOLUME 12A

ARMSTRONG LABORATORY

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PREFACE

Reports in this volume are numbered consecutively beginning with number 1. Each report is paginated with the report number followed by consecutive page numbers, e.g., 1-1, 1-2, 1-3; 2-1, 2-2, 2-3.

Due to its length, Volume 12 is bound in two parts, 12A and 12B. Volume 12A contains #1-22. Volume 12B contains reports #23-36. The Table of Contents for Volume 12 is included in both parts.

This document is one of a set of 16 volumes describing the 1996 AFOSR Summer Research Program. The following volumes comprise the set:

VOLUME	TITLE
1	Program Management Report
Summer Faculty Research Program (SFRP) Reports	
2A & 2B	Armstrong Laboratory
3A & 3B	Phillips Laboratory
4	Rome Laboratory
5A, 5B, & 5C	Wright Laboratory
6	Arnold Engineering Development Center, Frank J. Seiler Research Laboratory, and Wilford Hall Medical Center
Graduate Student Research Program (GSRP) Reports	
7A & 7B	Armstrong Laboratory
8	Phillips Laboratory
9	Rome Laboratory
10A & 10B	Wright Laboratory
11	Arnold Engineering Development Center, U.S. Air Force Academy, Wilford Hall Medical Center, and Wright Patterson Medical Center
High School Apprenticeship Program (HSAP) Reports	
12A & 12B	Armstrong Laboratory
13	Phillips Laboratory
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INTRODUCTION

The Summer Research Program (SRP), sponsored by the Air Force Office of Scientific Research (AFOSR), offers paid opportunities for university faculty, graduate students, and high school students to conduct research in U.S. Air Force research laboratories nationwide during the summer.

Introduced by AFOSR in 1978, this innovative program is based on the concept of teaming academic researchers with Air Force scientists in the same disciplines using laboratory facilities and equipment not often available at associates' institutions.

The Summer Faculty Research Program (SFRP) is open annually to approximately 150 faculty members with at least two years of teaching and/or research experience in accredited U.S. colleges, universities, or technical institutions. SFRP associates must be either U.S. citizens or permanent residents.

The Graduate Student Research Program (GSRP) is open annually to approximately 100 graduate students holding a bachelor's or a master's degree; GSRP associates must be U.S. citizens enrolled full time at an accredited institution.

The High School Apprentice Program (HSAP) annually selects about 125 high school students located within a twenty mile commuting distance of participating Air Force laboratories.

AFOSR also offers its research associates an opportunity, under the Summer Research Extension Program (SREP), to continue their AFOSR-sponsored research at their home institutions through the award of research grants. In 1994 the maximum amount of each grant was increased from $20,000 to $25,000, and the number of AFOSR-sponsored grants decreased from 75 to 60. A separate annual report is compiled on the SREP.

The numbers of projected summer research participants in each of the three categories and SREP "grants" are usually increased through direct sponsorship by participating laboratories.

AFOSR's SRP has well served its objectives of building critical links between Air Force research laboratories and the academic community, opening avenues of communications and forging new research relationships between Air Force and academic technical experts in areas of national interest, and strengthening the nation's efforts to sustain careers in science and engineering. The success of the SRP can be gauged from its growth from inception (see Table 1) and from the favorable responses the 1996 participants expressed in end-of-tour SRP evaluations (Appendix B).

AFOSR contracts for administration of the SRP by civilian contractors. The contract was first awarded to Research & Development Laboratories (RDL) in September 1990. After

completion of the 1990 contract, RDL (in 1993) won the recompetition for the basic year and four 1-year options.

2. PARTICIPATION IN THE SUMMER RESEARCH PROGRAM

The SRP began with faculty associates in 1979; graduate students were added in 1982 and high school students in 1986. The following table shows the number of associates in the program each year.

YEAR	SRP Participation, by Year			TOTAL
	SFRP	GSRP	HSAP	
1979	70			70
1980	87			87
1981	87			87
1982	91	17		108
1983	101	53		154
1984	152	84		236
1985	154	92		246
1986	158	100	42	300
1987	159	101	73	333
1988	153	107	101	361
1989	168	102	103	373
1990	165	121	132	418
1991	170	142	132	444
1992	185	121	159	464
1993	187	117	136	440
1994	192	117	133	442
1995	190	115	137	442
1996	188	109	138	435

Beginning in 1993, due to budget cuts, some of the laboratories weren't able to afford to fund as many associates as in previous years. Since then, the number of funded positions has remained fairly constant at a slightly lower level.

3. RECRUITING AND SELECTION

The SRP is conducted on a nationally advertised and competitive-selection basis. The advertising for faculty and graduate students consisted primarily of the mailing of 8,000 52-page SRP brochures to chairpersons of departments relevant to AFOSR research and to administrators of grants in accredited universities, colleges, and technical institutions. Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) were included. Brochures also went to all participating USAF laboratories, the previous year's participants, and numerous individual requesters (over 1000 annually).

RDL placed advertisements in the following publications: *Black Issues in Higher Education, Winds of Change,* and *IEEE Spectrum.* Because no participants list either *Physics Today* or *Chemical & Engineering News* as being their source of learning about the program for the past several years, advertisements in these magazines were dropped, and the funds were used to cover increases in brochure printing costs.

High school applicants can participate only in laboratories located no more than 20 miles from their residence. Tailored brochures on the HSAP were sent to the head counselors of 180 high schools in the vicinity of participating laboratories, with instructions for publicizing the program in their schools. High school students selected to serve at Wright Laboratory's Armament Directorate (Eglin Air Force Base, Florida) serve eleven weeks as opposed to the eight weeks normally worked by high school students at all other participating laboratories.

Each SFRP or GSRP applicant is given a first, second, and third choice of laboratory. High school students who have more than one laboratory or directorate near their homes are also given first, second, and third choices.

Laboratories make their selections and prioritize their nominees. AFOSR then determines the number to be funded at each laboratory and approves laboratories' selections.

Subsequently, laboratories use their own funds to sponsor additional candidates. Some selectees do not accept the appointment, so alternate candidates are chosen. This multi-step selection procedure results in some candidates being notified of their acceptance after scheduled deadlines. The total applicants and participants for 1996 are shown in this table.

1996 Applicants and Participants			
PARTICIPANT CATEGORY	TOTAL APPLICANTS	SELECTEES	DECLINING SELECTEES
SFRP	572	188	39
(HBCU/MI)	(119)	(27)	(5)
GSRP	235	109	7
(HBCU/MI)	(18)	(7)	(1)
HSAP	474	138	8
TOTAL	1281	435	54

4.   SITE VISITS

During June and July of 1996, representatives of both AFOSR/NI and RDL visited each participating laboratory to provide briefings, answer questions, and resolve problems for both laboratory personnel and participants. The objective was to ensure that the SRP would be as constructive as possible for all participants. Both SRP participants and RDL representatives found these visits beneficial. At many of the laboratories, this was the only opportunity for all participants to meet at one time to share their experiences and exchange ideas.

5.   HISTORICALLY BLACK COLLEGES AND UNIVERSITIES AND MINORITY INSTITUTIONS (HBCU/MIs)

Before 1993, an RDL program representative visited from seven to ten different HBCU/Mis annually to promote interest in the SRP among the faculty and graduate students. These efforts were marginally effective, yielding a doubling of HBCI/MI applicants. In an effort to achieve AFOSR's goal of 10% of all applicants and selectees being HBCU/MI qualified, the RDL team decided to try other avenues of approach to increase the number of qualified applicants. Through the combined efforts of the AFOSR Program Office at Bolling AFB and RDL, two very active minority groups were found, HACU (Hispanic American Colleges and Universities) and AISES (American Indian Science and Engineering Society). RDL is in communication with representatives of each of these organizations on a monthly basis to keep up with the their activities and special events. Both organizations have widely-distributed magazines/quarterlies in which RDL placed ads.

Since 1994 the number of both SFRP and GSRP HBCU/MI applicants and participants has increased ten-fold, from about two dozen SFRP applicants and a half dozen selectees to over 100 applicants and two dozen selectees, and a half-dozen GSRP applicants and two or three selectees to 18 applicants and 7 or 8 selectees. Since 1993, the SFRP had a two-fold applicant

increase and a two-fold selectee increase. Since 1993, the GSRP had a three-fold applicant increase and a three to four-fold increase in selectees.

In addition to RDL's special recruiting efforts, AFOSR attempts each year to obtain additional funding or use leftover funding from cancellations the past year to fund HBCU/MI associates. This year, 5 HBCU/MI SFRPs declined after they were selected (and there was no one qualified to replace them with). The following table records HBCU/MI participation in this program.

SRP HBCU/MI Participation, By Year				
YEAR	SFRP		GSRP	
	Applicants	Participants	Applicants	Participants
1985	76	23	15	11
1986	70	18	20	10
1987	82	32	32	10
1988	53	17	23	14
1989	39	15	13	4
1990	43	14	17	3
1991	42	13	8	5
1992	70	13	9	5
1993	60	13	6	2
1994	90	16	11	6
1995	90	21	20	8
1996	119	27	18	7

6. SRP FUNDING SOURCES

Funding sources for the 1996 SRP were the AFOSR-provided slots for the basic contract and laboratory funds. Funding sources by category for the 1996 SRP selected participants are shown here.

1996 SRP FUNDING CATEGORY	SFRP	GSRP	HSAP
AFOSR Basic Allocation Funds	141	85	123
USAF Laboratory Funds	37	19	15
HBCU/MI By AFOSR (Using Procured Addn'l Funds)	10	5	0
TOTAL	188	109	138

SFRP - 150 were selected, but nine canceled too late to be replaced.
GSRP - 90 were selected, but five canceled too late to be replaced (10 allocations for the ALCs were withheld by AFOSR.)
HSAP - 125 were selected, but two canceled too late to be replaced.

7.   COMPENSATION FOR PARTICIPANTS

Compensation for SRP participants, per five-day work week, is shown in this table.

1996 SRP Associate Compensation

PARTICIPANT CATEGORY	1991	1992	1993	1994	1995	1996
Faculty Members	$690	$718	$740	$740	$740	$770
Graduate Student (Master's Degree)	$425	$442	$455	$455	$455	$470
Graduate Student (Bachelor's Degree)	$365	$380	$391	$391	$391	$400
High School Student (First Year)	$200	$200	$200	$200	$200	$200
High School Student (Subsequent Years)	$240	$240	$240	$240	$240	$240

The program also offered associates whose homes were more than 50 miles from the laboratory an expense allowance (seven days per week) of $50/day for faculty and $40/day for graduate students. Transportation to the laboratory at the beginning of their tour and back to their home destinations at the end was also reimbursed for these participants. Of the combined SFRP and

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GSRP associates, 65 % (194 out of 297) claimed travel reimbursements at an average round-trip cost of $780.

Faculty members were encouraged to visit their laboratories before their summer tour began. All costs of these orientation visits were reimbursed. Forty-five percent (85 out of 188) of faculty associates took orientation trips at an average cost of $444. By contrast, in 1993, 58 % of SFRP associates took orientation visits at an average cost of $685; that was the highest percentage of associates opting to take an orientation trip since RDL has administered the SRP, and the highest average cost of an orientation trip. These 1993 numbers are included to show the fluctuation which can occur in these numbers for planning purposes.

Program participants submitted biweekly vouchers countersigned by their laboratory research focal point, and RDL issued paychecks so as to arrive in associates' hands two weeks later.

In 1996, RDL implemented direct deposit as a payment option for SFRP and GSRP associates. There were some growing pains. Of the 128 associates who opted for direct deposit, 17 did not check to ensure that their financial institutions could support direct deposit (and they couldn't), and eight associates never did provide RDL with their banks' ABA number (direct deposit bank routing number), so only 103 associates actually participated in the direct deposit program. The remaining associates received their stipend and expense payments via checks sent in the US mail.

HSAP program participants were considered actual RDL employees, and their respective state and federal income tax and Social Security were withheld from their paychecks. By the nature of their independent research, SFRP and GSRP program participants were considered to be consultants or independent contractors. As such, SFRP and GSRP associates were responsible for their own income taxes, Social Security, and insurance.

8.   CONTENTS OF THE 1996 REPORT

The complete set of reports for the 1996 SRP includes this program management report (Volume 1) augmented by fifteen volumes of final research reports by the 1996 associates, as indicated below:

1996 SRP Final Report Volume Assignments

LABORATORY	SFRP	GSRP	HSAP
Armstrong	2	7	12
Phillips	3	8	13
Rome	4	9	14
Wright	5A, 5B	10	15
AEDC, ALCs, WHMC	6	11	16

APPENDIX A – PROGRAM STATISTICAL SUMMARY

A. Colleges/Universities Represented

Selected SFRP associates represented 169 different colleges, universities, and institutions, GSRP associates represented 95 different colleges, universities, and institutions.

B. States Represented

SFRP -Applicants came from 47 states plus Washington D.C. and Puerto Rico. Selectees represent 44 states plus Puerto Rico.

GSRP - Applicants came from 44 states and Puerto Rico. Selectees represent 32 states.

HSAP - Applicants came from thirteen states. Selectees represent nine states.

Total Number of Participants	
SFRP	188
GSRP	109
HSAP	138
TOTAL	435

Degrees Represented			
	SFRP	GSRP	TOTAL
Doctoral	184	1	185
Master's	4	48	52
Bachelor's	0	60	60
TOTAL	188	109	297

SFRP Academic Titles	
Assistant Professor	79
Associate Professor	59
Professor	42
Instructor	3
Chairman	0
Visiting Professor	1
Visiting Assoc. Prof.	0
Research Associate	4
TOTAL	188

Source of Learning About the SRP		
Category	Applicants	Selectees
Applied/participated in prior years	28%	34%
Colleague familiar with SRP	19%	16%
Brochure mailed to institution	23%	17%
Contact with Air Force laboratory	17%	23%
IEEE Spectrum	2%	1%
BIIHE	1%	1%
Other source	10%	8%
TOTAL	100%	100%

APPENDIX B -- SRP EVALUATION RESPONSES

1. OVERVIEW

Evaluations were completed and returned to RDL by four groups at the completion of the SRP. The number of respondents in each group is shown below.

Table B-1. Total SRP Evaluations Received

Evaluation Group	Responses
SFRP & GSRPs	275
HSAPs	113
USAF Laboratory Focal Points	84
USAF Laboratory HSAP Mentors	6

All groups indicate unanimous enthusiasm for the SRP experience.

The summarized recommendations for program improvement from both associates and laboratory personnel are listed below:

A.   Better preparation on the labs' part prior to associates' arrival (i.e., office space, computer assets, clearly defined scope of work).

B.   Faculty Associates suggest higher stipends for SFRP associates.

C.   Both HSAP Air Force laboratory mentors and associates would like the summer tour extended from the current 8 weeks to either 10 or 11 weeks; the groups state it takes 4-6 weeks just to get high school students up-to-speed on what's going on at laboratory. (Note: this same argument was used to raise the faculty and graduate student participation time a few years ago.)

2. 1996 USAF LABORATORY FOCAL POINT (LFP) EVALUATION RESPONSES

The summarized results listed below are from the 84 LFP evaluations received.

1. LFP evaluations received and associate preferences:

Table B-2. Air Force LFP Evaluation Responses (By Type)

Lab	Evals Recv'd	How Many Associates Would You Prefer To Get ? (% Response)											
		SFRP				GSRP (w/Univ Professor)				GSRP (w/o Univ Professor)			
		0	1	2	3+	0	1	2	3+	0	1	2	3+
AEDC	0	-	-	-	-	-	-	-	-	-	-	-	-
WHMC	0	-	-	-	-	-	-	-	-	-	-	-	-
AL	7	28	28	28	14	54	14	28	0	86	0	14	0
FJSRL	1	0	100	0	0	100	0	0	0	0	100	0	0
PL	25	40	40	16	4	88	12	0	0	84	12	4	0
RL	5	60	40	0	0	80	10	0	0	100	0	0	0
WL	46	30	43	20	6	78	17	4	0	93	4	2	0
Total	84	32%	50%	13%	5%	80%	11%	6%	0%	73%	23%	4%	0%

LFP Evaluation Summary. The summarized responses, by laboratory, are listed on the following page. LFPs were asked to rate the following questions on a scale from 1 (below average) to 5 (above average).

2. LFPs involved in SRP associate application evaluation process:
    a. Time available for evaluation of applications:
    b. Adequacy of applications for selection process:
3. Value of orientation trips:
4. Length of research tour:
5   a. Benefits of associate's work to laboratory:
    b. Benefits of associate's work to Air Force:
6.   a. Enhancement of research qualifications for LFP and staff:
    b. Enhancement of research qualifications for SFRP associate:
    c. Enhancement of research qualifications for GSRP associate:
7.   a. Enhancement of knowledge for LFP and staff:
    b. Enhancement of knowledge for SFRP associate:
    c. Enhancement of knowledge for GSRP associate:
8. Value of Air Force and university links:
9. Potential for future collaboration:
10.   a. Your working relationship with SFRP:
    b. Your working relationship with GSRP:
11. Expenditure of your time worthwhile:

<div align="center">(Continued on next page)</div>

12. Quality of program literature for associate:
13.   a. Quality of RDL's communications with you:
      b. Quality of RDL's communications with associates:
14. Overall assessment of SRP:

Table B-3. Laboratory Focal Point Reponses to above questions

	AEDC	AL	FJSRL	PL	RL	WHMC	WL
# Evals Recv'd	0	7	1	14	5	0	46
Question #							
2	-	86 %	0 %	88 %	80 %	-	85 %
2a	-	4.3	n/a	3.8	4.0	-	3.6
2b	-	4.0	n/a	3.9	4.5	-	4.1
3	-	4.5	n/a	4.3	4.3	-	3.7
4	-	4.1	4.0	4.1	4.2	-	3.9
5a	-	4.3	5.0	4.3	4.6	-	4.4
5b	-	4.5	n/a	4.2	4.6	-	4.3
6a	-	4.5	5.0	4.0	4.4	-	4.3
6b	-	4.3	n/a	4.1	5.0	-	4.4
6c	-	3.7	5.0	3.5	5.0	-	4.3
7a	-	4.7	5.0	4.0	4.4	-	4.3
7b	-	4.3	n/a	4.2	5.0	-	4.4
7c	-	4.0	5.0	3.9	5.0	-	4.3
8	-	4.6	4.0	4.5	4.6	-	4.3
9	-	4.9	5.0	4.4	4.8	-	4.2
10a	-	5.0	n/a	4.6	4.6	-	4.6
10b	-	4.7	5.0	3.9	5.0	-	4.4
11	-	4.6	5.0	4.4	4.8	-	4.4
12	-	4.0	4.0	4.0	4.2	-	3.8
13a	-	3.2	4.0	3.5	3.8	-	3.4
13b	-	3.4	4.0	3.6	4.5	-	3.6
14	-	4.4	5.0	4.4	4.8	-	4.4

3. 1996 SFRP & GSRP EVALUATION RESPONSES

The summarized results listed below are from the 257 SFRP/GSRP evaluations received.

Associates were asked to rate the following questions on a scale from 1 (below average) to 5 (above average) - by Air Force base results and over-all results of the 1996 evaluations are listed after the questions.

1. The match between the laboratories research and your field:
2. Your working relationship with your LFP:
3. Enhancement of your academic qualifications:
4. Enhancement of your research qualifications:
5. Lab readiness for you: LFP, task, plan:
6. Lab readiness for you: equipment, supplies, facilities:
7. Lab resources:
8. Lab research and administrative support:
9. Adequacy of brochure and associate handbook:
10. RDL communications with you:
11. Overall payment procedures:
12. Overall assessment of the SRP:
13.   a. Would you apply again?
        b. Will you continue this or related research?
14. Was length of your tour satisfactory?
15. Percentage of associates who experienced difficulties in finding housing:
16. Where did you stay during your SRP tour?
        a.   At Home:
        b.   With Friend:
        c.   On Local Economy:
        d.   Base Quarters:
17. Value of orientation visit:
        a.   Essential:
        b.   Convenient:
        c.   Not Worth Cost:
        d.   Not Used:

SFRP and GSRP associate's responses are listed in tabular format on the following page.

Table B-4.   1996 SFRP & GSRP Associate Responses to SRP Evaluation

	Arnold	Brooks	Edwards	Eglin	Griffis	Hanscom	Kelly	Kirtland	Lackland	Robins	Tyndall	WPAFB	average
# res	6	48	6	14	31	19	3	32	1	2	10	85	257
1	4.8	4.4	4.6	4.7	4.4	4.9	4.6	4.6	5.0	5.0	4.0	4.7	4.6
2	5.0	4.6	4.1	4.9	4.7	4.7	5.0	4.7	5.0	5.0	4.6	4.8	4.7
3	4.5	4.4	4.0	4.6	4.3	4.2	4.3	4.4	5.0	5.0	4.5	4.3	4.4
4	4.3	4.5	3.8	4.6	4.4	4.4	4.3	4.6	5.0	4.0	4.4	4.5	4.5
5	4.5	4.3	3.3	4.8	4.4	4.5	4.3	4.2	5.0	5.0	3.9	4.4	4.4
6	4.3	4.3	3.7	4.7	4.4	4.5	4.0	3.8	5.0	5.0	3.8	4.2	4.2
7	4.5	4.4	4.2	4.8	4.5	4.3	4.3	4.1	5.0	5.0	4.3	4.3	4.4
8	4.5	4.6	3.0	4.9	4.4	4.3	4.3	4.5	5.0	5.0	4.7	4.5	4.5
9	4.7	4.5	4.7	4.5	4.3	4.5	4.7	4.3	5.0	5.0	4.1	4.5	4.5
10	4.2	4.4	4.7	4.4	4.1	4.1	4.0	4.2	5.0	4.5	3.6	4.4	4.3
11	3.8	4.1	4.5	4.0	3.9	4.1	4.0	4.0	3.0	4.0	3.7	4.0	4.0
12	5.7	4.7	4.3	4.9	4.5	4.9	4.7	4.6	5.0	4.5	4.6	4.5	4.6
Numbers below are percentages													
13a	83	90	83	93	87	75	100	81	100	100	100	86	87
13b	100	89	83	100	94	98	100	94	100	100	100	94	93
14	83	96	100	90	87	80	100	92	100	100	70	84	88
15	17	6	0	33	20	76	33	25	0	100	20	8	39
16a	-	26	17	9	38	23	33	4	-	-	-	30	
16b	100	33	-	40	-	8	-	-	-	-	36	2	
16c	-	41	83	40	62	69	67	96	100	100	64	68	
16d	-	-	-	-	-	-	-	-	-	-	-	0	
17a	-	33	100	17	50	14	67	39	-	50	40	31	35
17b	-	21	-	17	10	14	-	24	-	50	20	16	16
17c	-	-	-	-	10	7	-	-	-	-	-	2	3
17d	100	46	-	66	30	69	33	37	100	-	40	51	46

4. 1996 USAF LABORATORY HSAP MENTOR EVALUATION RESPONSES

Not enough evaluations received (5 total) from Mentors to do useful summary.

5. 1996 HSAP EVALUATION RESPONSES

The summarized results listed below are from the 113 HSAP evaluations received.

HSAP apprentices were asked to rate the following questions on a scale from
1 (below average) to 5 (above average)

1. Your influence on selection of topic/type of work.
2. Working relationship with mentor, other lab scientists.
3. Enhancement of your academic qualifications.
4. Technically challenging work.
5. Lab readiness for you: mentor, task, work plan, equipment.
6. Influence on your career.
7. Increased interest in math/science.
8. Lab research & administrative support.
9. Adequacy of RDL's Apprentice Handbook and administrative materials.
10. Responsiveness of RDL communications.
11. Overall payment procedures.
12. Overall assessment of SRP value to you.
13. Would you apply again next year?   Yes (92 %)
14. Will you pursue future studies related to this research?   Yes (68 %)
15. Was Tour length satisfactory?   Yes (82 %)

	Arnold	Brooks	Edwards	Eglin	Griffiss	Hanscom	Kirtland	Tyndall	WPAFB	Totals
# resp	5	19	7	15	13	2	7	5	40	113
1	2.8	3.3	3.4	3.5	3.4	4.0	3.2	3.6	3.6	3.4
2	4.4	4.6	4.5	4.8	4.6	4.0	4.4	4.0	4.6	4.6
3	4.0	4.2	4.1	4.3	4.5	5.0	4.3	4.6	4.4	4.4
4	3.6	3.9	4.0	4.5	4.2	5.0	4.6	3.8	4.3	4.2
5	4.4	4.1	3.7	4.5	4.1	3.0	3.9	3.6	3.9	4.0
6	3.2	3.6	3.6	4.1	3.8	5.0	3.3	3.8	3.6	3.7
7	2.8	4.1	4.0	3.9	3.9	5.0	3.6	4.0	4.0	3.9
8	3.8	4.1	4.0	4.3	4.0	4.0	4.3	3.8	4.3	4.2
9	4.4	3.6	4.1	4.1	3.5	4.0	3.9	4.0	3.7	3.8
10	4.0	3.8	4.1	3.7	4.1	4.0	3.9	2.4	3.8	3.8
11	4.2	4.2	3.7	3.9	3.8	3.0	3.7	2.6	3.7	3.8
12	4.0	4.5	4.9	4.6	4.6	5.0	4.6	4.2	4.3	4.5
Numbers below are percentages										
13	60%	95%	100%	100%	85%	100%	100%	100%	90%	92%
14	20%	80%	71%	80%	54%	100%	71%	80%	65%	68%
15	100%	70%	71%	100%	100%	50%	86%	60%	80%	82%

CHEMICAL PREPARATIONS OF DRINKING WATER
FOR RADIOANALYSIS

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CHEMICAL PREPARATIONS OF DRINKING WATER
FOR RADIOANANALYSIS

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Abstract

Preparation of water samples from bases around the U.S. for radioanalytical purposes was studied. A well mixed, acidified water sample is evaporated, acid-digested, and the residue transferred to 2" planchet. These samples are then counted for gross alpha and gross beta radioactivity. The results indicated that the drinking water samples prepared met the EPA's drinking water standard. However, when the samples do not meet the standards, they are then re-tested or tested for uranium or radium.

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CHEMICAL PREPARATIONS OF DRINKING WATER
FOR RADIOANALYSIS

Julio E. Ayala II

Introduction

The purpose of this introduction is to explain the basic principles of radiation. Radiation is a process of transmitting energy through space. Such radiation consists of waves or particles. Waves and particles have many characteristics in common. Mechanical radiation consists of waves, such as sound waves, that are transmitted only through matter. Electromagnetic radiation is independent of matter for its propagation; speed, amount, and direction of energy, however, are influenced by the presence of matter. This radiation occurs in a wide variety of energies, with visible light approximately in the middle of the range. Electromagnetic radiation carrying adequate amount of energy to bring about changes in atoms that it strikes is called ionizing radiation. Particle radiation can also be ionizing if it carries enough energy. Like electromagnetic radiation, which it simulates, it does not require matter for its propagation. Examples of particle radiation are cosmic rays, alpha rays, and beta rays. Cosmic rays are streams of positively charged nuclei, mainly those of hydrogen. Cosmic rays may also contain electrons, protons, gamma rays, pions, and muons. Alpha rays are streams of positively charged helium nuclei. Beta rays are streams of electrons. Ionizing radiation has different penetrating properties that are important in the study and use of radioactive materials. Naturally occurring alpha rays are stopped by the thickness of a few sheets of paper or a rubber glove. Beta rays are stopped by a few centimeters of wood. Gamma rays and X-rays, depending on their energies, require thick shielding of a heavy material such as iron, lead, or concrete.

When ionizing radiation interacts with living tissue by transferring energy to molecules of cellular matter can cause biological effects. Cellular function may be temporarily or permanently impaired as a result of such interaction, or the cells may be demolished. The severity of the injury depends on the type of radiation, the absorbed dose, the rate at which the dose was absorbed, and the radiosensitivity of the tissues involved. The effects are the same, whether from a radiation source outside the body or from material within.

The biological effects of a large dose of radiation delivered rapidly differ greatly from those of the same dose delivered slowly. The effects of rapid delivery are due to cell death, and they become apparent within hours, days, or weeks. Protracted exposure is better admissible because some of the damage is repaired while the exposure continues, even if the total dose is relatively high. If the dose is adequate to cause acute clinical effects, however, repair is less likely and may be slow even if it does occur. Exposure to doses of radiation too low to destroy cells can prompt cellular changes that may be detectable clinically only after some years.

Acute effects of radiation can be caused when a living organism acquires high whole-body doses of radiation to produce a characteristic pattern of injury. Doses are measured in rads (radiation absorbed dose) in which 1 rad is equal to an amount of radiation that deposits 100 ergs of energy per gram of matter. Doses of more than 4000 rads can cause extreme damage to the human vascular system causing cerebral edema. Cerebral edema leads to intense shock and neurological disturbances in which death occurs within 48 hours. Less severe vascular damage is caused if whole-body doses of 1000 to 4000 rads is received, which leads to loss of fluids and electrolytes into the intercellular spaces and the gastrointestinal tract. Death will occur within ten days as a result of fluid and electrolyte imbalance, severe bone-marrow damage, and terminal infection. When a person absorbs doses of 150 to 1000 rads, the destruction of human bone marrow with an infection and hemorrhage will occur. Death can be expected about four to five weeks after exposure if it ever occurs. Currently only the effects of the lower doses can be treated effectively. If it is untreated, half of the exposed people receiving as little as 300 to 325 rads to the bone marrow will die. The most frequent kind of radiation accident is exposure of small areas of the body which leads to concentrated tissue damage. Damage blood vessels in exposed areas causes disturbed organ function and, at higher doses, necrosis (localized tissue death) and gangrene.

Nonmalignant delayed effects of ionizing radiation are manifested in many organs - particularly bone marrow, kidneys, lungs, and the lens of the eye - by retrograde changes and impaired function. These effects are largely secondary to radiation-induced damage to blood vessels. However, the most important late effect of radiation exposure is an increased incidence of cancers and leukemia of the types that occur

naturally in nonexposed individuals. Statistics show that only in populations exposed to relatively high doses of radiation (greater than 100 rads) have significant increases in leukemia and of cancers of the thyroid, the lung, and the female breast. However, nonspecific life-shortening effects suggested by animal experiments have not yet been demonstrated in humans.

Because exposure to ionizing radiation carries a risk, it would be impossible to avoid it entirely. It has been said that radiation has always been present in the environment and within human bodies. But undue exposure can be avoided. There are simple, sensitive instruments capable of detecting minute amounts if radiation from natural and man-made sources. In addition there are four known ways for humans to protect themselves - time, distance, shielding, and containment. People who are exposed to radiation through work and with natural background radiation, the dose can be reduced and the risk of illness can be made to zero if the exposure time is limited. The intensity of radiation decreases the further away humans are from the radiation source. Barriers of lead, concrete, or water give good protection from penetrating radiation. Therefore radioactive materials are often stored and handled under water, or by remote control in rooms constructed of thick concrete or lined with lead. Radioactive materials are confined in the smallest possible space and kept out of the environment. For example, radioactive isotopes for medical use are dispensed in closed handling facilities, while nuclear reactors operate within closed systems with multiple barriers which keep the radioactive materials contained.

Biological effects of radiation can be caused not only by exposure but also by ingestion. Drinking water is a prime example of ingestion of radiation because there are naturally occurring radionuclides found in drinking water supplies. There are acute and long-term effects similar to those of the external exposure effects.

Discussion of Problem

Nearly all radionuclides occurring in drinking water supplies are naturally occurring. The radionuclides will vary somewhat according to the source of water. According to the Safe Drinking Water Act, public drinking water supplies are defined as those that serve 25 or more people or have 15 or more service connections. Ground water sources provide water to 80% of the nation's 60,000 public water supplies. Nearly 70% of the population use surface water as their public drinking water supplies.

There are three natural radioactive elements that all radionuclides in drinking water are members of. Radium (Ra), radon (Rn), and uranium (U) are the specific elements of concern. Health risks are posed by isotopes in the uranium series because of their presence in drinking water are ^{238}U, ^{234}U, ^{226}Ra, and ^{222}Rn. Also found in drinking water is Radium-228, which is part of the thorium series. Very few of the other isotopes in these series have been detected in drinking water. However, recently in east central Florida, polonium-210 has been detected in the drinking water.

According to a survey conducted by the Interim Drinking Water Regulations, it was estimated that approximately 500 of 60,000 public drinking water supplies have levels of radium that exceed the interim MCL (maximum contaminant level) of 5 pCi/L. The interim drinking water standard applies to combined ^{226}Ra and ^{228}Ra. Although the occurrence of ^{226}Ra and ^{228}Ra are independent (they occur in two different radioactive series), their nationwide distributions with respect to concentration are somewhat similar. Approximately 100 pCi/L has been the largest concentration measured in public drinking water supplies. The mean for ^{226}Ra is approximately 0.4 pCi/L, and the mean for ^{228}Ra is approximately 0.7 pCi/L.

Radon in drinking water can be found only in groundwater supplies. Smaller water supplies usually get their water from small aquifers in which they have larger granular surface areas and, thus, having higher concentrations of radon. As a result, smaller communities tend to have high levels of radon in the drinking water. It is expected, based on this trend, that radon occurrences in private wells will be three to ten times higher than concentrations measured in public drinking water supplies. Waterborne radon enters a house through the water supply and released inside the house when water is used for

flushing toilets, cooking, bathing, washing clothes, and washing dishes. Exposure more likely if one inhales radon but less likely if they ingest it through drinking water or beverages.

Primarily, this project is to prepare drinking water samples sent from bases all over the United States to be tested for radioactivity. The samples must meet the Environmental Protection Agency's standards, standards which have to be followed, or else the drinking water is considered undrinkable due to high concentrations of radioactivity. The samples are tested and re-tested for thorough analysis.

Methodology

Naturally occurring radioactive elements, such as uranium, thorium, and radium, have radioactive daughters that contribute to the radioactivity of and groundwaters. Radioactive elements produced from the operation of nuclear reactors and other radionuclide-generating devices may add to this natural effect. The Environmental Protection Agency (EPA) has established maximum contaminant levels for radium-226, radium-228 (combined, 5 pCi/L), and gross alpha (including radium-226 but excluding radon and uranium, 15 pCi/L) in drinking water. A well mixed, acidified water sample is evaporated, acid digested, and the residue transferred to a 2" planchet. A thin-window gas-flow proportional counter is used to count for gross alpha and gross beta radioactivity. Counting activities are determined using the counting efficiency for different volumes of spiked synthetic water samples similarly prepared.

All Reagents used should be at least reagent grade and water should be distilled or demineralized. Reagents needed are:

Americium 241 standardized solution, ~ 11 pCi/mL

Cesium 137 standardized solution, ~ 68 pCi/mL

Nitric acid, HNO_3 16 N (conc.)

Nitric acid, HNO_3 8 N. Add 500 mL 16 N HNO_3 to 400 mL water and dilute to 1 L with water.

Nitric acid, HNO_3 0.1 N. Add 12.5 mL 8 N HNO_3 to 500 mL water and dilute to 1 L with water.

Synthetic salt solution: Dissolve 2.0 g $NaHCO_3$ (sodium bicarbonate), 1.2 $CaCO_3$ (calcium

sulfate), 1.2 g $MgSO_4$ (magnesium sulfate) in 4 liters water. Dilute to 20 liters with water.

Quality control is that for each batch of 10 samples, or less, process 1 blank, 1 spike, and 1 duplicate spike using the synthetic solution.

Procedure:

1. Label each beaker and planchet. Weigh planchet for their tare weight.

2. For the blank and the spikes, use 200 mL of synthetic solution. Add ~ 11 pCi activity of Am^{241} and ~ 68 pCi activity of Cs^{137} to the spike and duplicate spike.

3. Transfer 200 mL of the well mixed sample to a 250 mL beaker. Evaporate the samples on a hotplate to near dryness (~ 10 mL). Cool the beaker, add 5 mL HNO_3 (conc.), and re-evaporate to near dryness. Repeat the digestion twice more with an additional 5 mL HNO_3 (conc.).

4. Dissolve the residue with 5 mL 0.1 N HNO_3 and evaporate to ~ 2 mL.

5. Quantitatively transfer the residue to a tared, flamed, 2", stainless steel planchet, policing, and rinsing the beaker with small amounts of 0.1 N HNO_3, repeat the transfer once more.

6. Evaporate to dryness on warm hotplate. Cool.

7. Weigh planchets and determine the sample net weight. Store sample in desiccator until ready for counting.

8. Complete the sample work card with the following information:

    1) Volume of the sample used for analysis.

    2) Gross, tare, and net weight of the water solids on the planchet.

    3) Completion date and initials of analyst.

9. Transport sample, with accompanying quality control samples, to the measurement section.

Counting:

Counting is accomplished according to OI's of the measurement section.

Calculations:

Calculations are accomplished according to OI's of the measurement section.

Calibration Curve:

Using the synthetic salt solution with the radioactive solutions in which it will be prepared and counted exactly as regular samples.

Notes:

1. If the net weight of the samples is > 100 mg, flame the planchet to evaporate residual moisture, or repeat the preparation method using a sample volume of < 100 mL.

2. If measurements are not in compliance with EPA's drinking water standards, they are re-tested to measure for specific radionuclides. For a better understanding, follow the flow chart on page 1-11.

EPA DRINKING WATER STANDARD

```
                    ┌─────────────────────────┐
                    │   Measure Gross Alpha   │
                    └─────────────────────────┘
                                 │
                                 ▼
                           ╱  pCi/L  ╲
┌──────────────┐      ╱               ╲
│  Compliance  │◄──── < 5    > 5 and < 15  ────┐
└──────────────┘      ╲               ╱        │
                           ╲  > 15  ╱          │
                                 │              ▼
                                 ▼        ┌─────────────────────────┐
                    ┌─────────────────────│      Measure Ra 226     │◄──┐
                    │  Measure Uranium    │─────────────────────────│   │
                    │                     │    < 3 pCi/L Ra 226     │   │
                    ├─────────────────────│─────────────────────────│   │
                    │ Alpha-(Radon+Uranium)│   > 3 pCi/L Ra 226     │   │
                    │                     │                         │   │
                    │    < 5 pCi/L        │   ┌──────────────┐       │   │
                    ├─────────────────────│──►│  Compliance  │       │   │
                    │ Alpha-(Radon+Uranium)│  └──────────────┘       │   │
                    │ including Ra 226    │                          │   │
                    │                     │   ┌─────────────────────┐│   │
                    │ > 5 pCi/L but < 15  │   │   Measure Ra 228    ││   │
                    ├─────────────────────│   │─────────────────────││   │
                    │ Alpha-(Radon+Uranium)│  │   < 5 pCi/L Ra 226  ││   │
                    │ including Ra 226    │   │─────────────────────││   │
                    │                     │   │   > 5 pCi/L Ra 226  ││   │
                    │    > 15 pCi/L       │   └─────────────────────┘│   │
                    └─────────────────────┘                          │   │
                           ┌──────────────┐                          │   │
                           │Non-compliance│                          │   │
                           └──────────────┘                          │   │
```
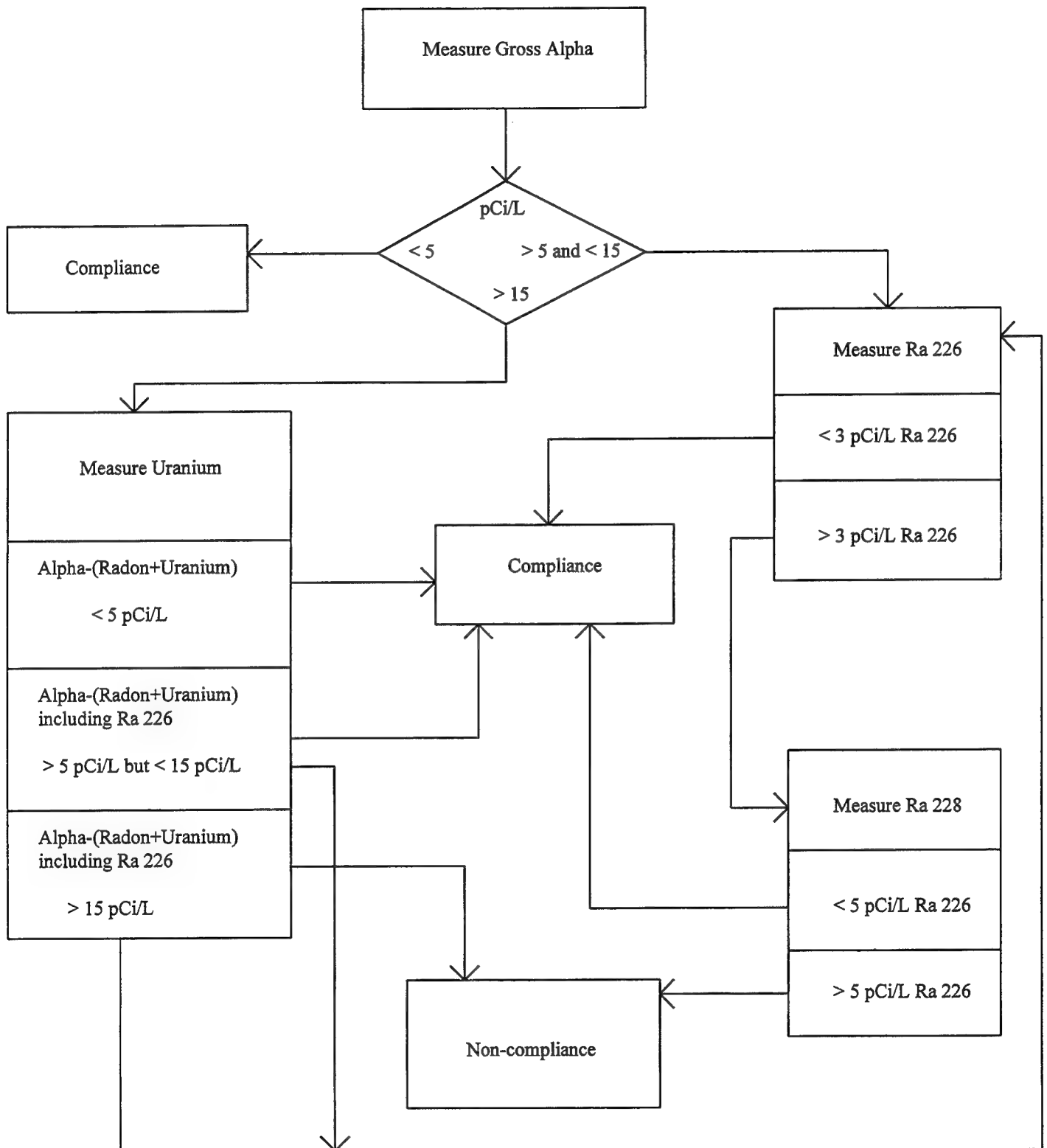
Results

Similar results occurred after preparing more than eight batches of drinking water samples. The blanks and spikes met the range of expected activity for gross alpha but many problems took place with the gross beta. As a result, they were counted once again to restore any faults which occurred in the previous count. If the same results are presented again, then the preparation of the blanks and spikes must be executed again. Every drinking water sample done have met the EPA's drinking water standard. The only problems which had occurred were with the preparations. Many times the samples had a net weight of over 100 milligrams. With the excess weight, counting could not be done accurately. The samples are then flamed to get them under 100 milligrams. Preparation of the sample with less volume resulted if the net weight was still over 100 milligrams. Along with drinking water, preparations of nonpotable water were done also. These were the toughest to do because no constant weight was measured and most were all over 100 milligrams. These samples are put in an oven to dry all excess moisture for 24 hours. Sometimes the weight became constant but most of the time they had to be prepared again with a less sample volume. Overall, the results came out relatively good with problems that were easily solved.

Conclusion

With the consequences of being exposed to radiation in any form, many places are taking concern in their water supplies. Bases are sending drinking water to Armstrong Laboratory to be tested for any radionuclides. Great progress resulted with the drinking water samples I prepared in my project. These samples were in compliance with EPA's drinking water standard. Only problems I had was with the spike solution with not meeting the range of expected activity but they eventually met the range when they were re-tested or prepared again. Overall, my experiment resulted with good figures.

Last, I would like to acknowledge the help of everyone in Radioanalytical Services at Armstrong Laboratory. I have become more knowledgeable with idea of radiation in our world. I would like to thank the Air Force Office of Scientific Research for giving me the opportunity to be in an advantageous program.

References

1. Cothern, C. Richard and Paul A. Rebers. *Radon, Radium and Uranium in Drinking Water* (Chelsea, MI: Lewis Publishers, Inc., 1991)

2. EPA Method 900.0, Gross Alpha and Gross Beta Activity in Drinking Waters, EPA-600/4-80-032.

3. Hall, Eric J. "Radiation and Life." http://www.uic.com.au/ral.htm (12 June 1996).

4. "Radiation," Microsoft Encarta. Copyright 1994 Microsoft Corporation. Copyright 1994 Funk & Wagnals Corporation.

5. "Radiation Related Terms." http.//www.sph.umich.edu/%7Ebbusby/terms.htm#top (12 June 1996).

Application of World Wide Web Technologies to Enhance Information Visualization

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APPLICATION OF WORLD WIDE WEB TECHNOLOGIES TO ENHANCE INFORMATION VISUALIZATION

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Abstract

The vast growth in capability of World Wide Web technology has brought a new way of communicating and sharing information into many offices. The Logistics Research Division of Armstrong Laboratory is exploring the option of using these technologies in logistics efforts. In order to assist in this endeavor, this project was designed to produce an example of the many capabilities of applying Virtual Reality Modeling Language (VRML) and HyperText Markup Language (HTML) to logistics. In this project, VRML worlds and HTML pages were created and connected to each other. A variety of aspects of the two languages were introduced. As the project developed, some problems were encountered. Among these were response time, file size, and product problems. Some had solutions while others may be fixed at a later time when solutions are discovered. In an effort to relate this project to logistics efforts, some examples were offered for further enhancement including aircraft maintenance manuals and training. Overall, this project was a success and can be used to learn about the many possibilities of using VRML and HTML in logistics.

APPLICATION OF WORLD WIDE WEB TECHNOLOGIES TO ENHANCE INFORMATION VISUALIZATION

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Introduction

In the past few years the world has seen an explosion in the capability of technology to serve as a communication and information sharing device. The ability to clearly communicate with almost anyone in the world is becoming better and faster every day. Information on every subject under the sun can be found using the technology available. With this vast treasure of information and communication available, it would be unwise for Armstrong Laboratory's Logistics Research Division (AL/HRG) to ignore the possibilities that are present through technology. This project intends to take a basic look at the benefits that can be derived from research and participation in this new and ever expanding field.

The piece of technology greatly responsible for bringing this explosion of communication to the general public is the World Wide Web. The World Wide Web (WWW or Web) is a hypertext based application that displays information formatted in HyperText Markup Language (HTML). This information is shared with the world through servers that access the information based on its Universal Reference Locator (URL). Every site or linked set of documents has a unique URL that allows anyone in the world connected to a server to access endless information. Images, video, sound, interactive conversations, and text documents are all available for use on the Web. One can even contribute to this mountain of information by creating HTML documents or home pages.

While most of the information accessible through the WWW is two dimensional, three dimensional sites are increasing in number daily. These three dimensional sites are called worlds and are created using Virtual Reality Modeling Language (VRML). One can walk through these three dimensional sites. Objects in these worlds may serve as links to HTML sites or other VRML worlds. These virtual worlds allow information to be presented in a way more familiar to humans. As information is displayed in three dimensions, organization and relationships are often understood easier since the information more closely resembles real-world objects.

Both HTML and VRML are relatively new languages and are constantly undergoing revisions and changes. HTML version 3.0 is currently supported by Netscape among others. The improvements made in HTML 3.0 include to ability to make text blink, change text color and size in the middle of the document, and to frame information into different sections. VRML version 2.0 is set to debut in the fall of 1996. Currently, few VRML viewers support VRML 2.0, but conversion software is popping up on the Web. Additions set to appear in VRML 2.0 are animation nodes, the ability to change the sky color, sound and video links, and collision detection for objects.

As mentioned previously, an internet browser is needed to view and access information on the Web. The three main browsers available for use are Mosaic, Microsoft Internet Explorer, and Netscape. While Mosaic was most widely used in the beginning, Netscape and Internet Explorer are now more popular as Web browsers. Their ability to support HTML 3.0 advancements and VRML in one application, which Mosaic cannot currently do, gives them the edge. Due to its advanced support of VRML extensions, Netscape was chosen for use in this project. While learning HTML and VRML, Netscape proved a great help. The option to view the document source file allows one to view the page or world side by side with the HTML or VRML the author wrote. Pairing up new or unfamiliar elements on pages or in worlds with their written counterpart using this tool saves the time of experimenting to achieve the same look in new pages or worlds.

Purpose

As the popularity of the Web increases, the various Web technologies are being applied in different areas. Armstrong Laboratory's Logistics Research Division (AL/HRG) is investigating the use of VRML and HTML in logistics applications. AL/HRG's mission includes finding more effective and efficient ways to display and enhance information to assist Air Force logistics personnel. VRML and HTML provide a new method of producing and presenting information, therefore offering another option for those who work in logistics. The ease with which information can be accessed and relationships between information understood can strengthen many people's work

environments. The division is also building an intranet and WWW home page for distributing research information. These two efforts were combined in this project which hopes to produce information helpful to both.

The objective of this summer research was to investigate, design, and develop an office intranet to show the capabilities of VRML and HTML. By demonstrating these capabilities in a small effort, division personnel were introduced to the benefits of these new technologies for possible application in existing and future logistics research efforts.

Methodology

To write a novel in English, one must first know the English language. The same is true for this project. To convey information in 2 or 3 dimensions on the World Wide Web, one must be fluent in the formatting languages of HTML and VRML. There are many ways to become proficient in a subject, trial-and-error and guided tutorials among them. In this case both mentioned methods came into use. Surfing the Web with little direction or aim allowed a first look at the medium at hand. Learning the basics of how to write and achieve elements came by reading on-line tutorials and reference pages. Trial and error followed as experimental pages and worlds came to life. Construction of simple pages utilizing several different elements such as tables, images, and frames and worlds using primitive shapes along with indexed face sets gave control of the learned elements. Once fluent, or at least proficient, in HTML and VRML, work on the project could begin.

The three dimensional model of the building was created first. A floor plan of the building aided in beginning the construction of the basic building structure. A checked and revised plan with a new scale and moveable walls added served as the blueprint for the virtual world. Walking through the building many times provided a reference as to what a virtual walk through should look like. The partner approach to this project dictated that each aspect of the building be made separately. This approach also helped keep file sizes manageable. While each floor was created in a separate file, the same basic procedure was used to create each floor. The permanent outside walls were constructed first, followed by the permanent walls inside. The moveable walls, or

cubicles, were created next. These walls were not placed exactly because they may be moved at any time. Setting them up in a simpler layout than they actually are allowed for increased navigation ease. All walls were constructed using transformed cubes, not indexed faces. This method was chosen because of the ease of using cubes. Most browsers also optimize cubes because they know how to deal with them. Using cubes meant that the door headers had to be added separately from the rest of the walls. This was the next step. While door headers were added, doors were not. This was done to allow easier viewing and navigation into rooms. During the process of placing the walls, the ceiling was omitted so that the position of the walls could be seen from the top. This gave a floor plan view of the world and made for easy comparison to the blueprint.

Once the walls had been installed in the building, the windows were made and placed. The graphic on the window uses a scanned picture of a tree. The graphic was modified to include a window frame. The resulting graphic textured on the cubes placed in the walls became the windows. The cubes were placed protruding from the walls at the appropriate place and height. Several different shapes of windows were created to account for the different windows present in the building. The windows can only be seen from the inside of each specific floor.

Once the basic structure of the building had been established, it was necessary to furnish the offices. The furniture, such as computers, desks, and chairs, was created from measurements taken off actual furniture. Sketches were then drawn showing each piece of furniture from all sides. These sketches were used to establish corners to be used as vertices. Once vertices were established, faces or planes were identified and inputted into the file specific for each piece of furniture. The final touches that went into creating the furniture included selecting a color for each face and choosing appropriate images to be used as texture maps. When simple colors could be used to make the furniture look more realistic, final touches were left to that. In some cases however, it was necessary to create graphics to place on objects. One such instance of this is a graphic of the keys on a keyboard being placed on a simple shape to add a realistic touch to the keyboard. Each piece of furniture was created in a separate file to allow repeated use throughout both floors. Once files were completed, they were transformed into the floors. Some pieces, like a table and computer, were placed in groups. Other pieces were used in many different combinations. Several areas on each floor were furnished to give the effect of a complete office building. Many offices remain empty. Furnishing every office would have slowed down navigation and made the world appear choppy. This is

due to the amount of information that can be refreshed each time. Keeping files small allows the browser to refresh everything more often, providing smoother navigation.

The next step taken was to construct a simple model of the entire building to be the starting world. The building model is meant to be viewed from the outside, with simple links in each doorway to enter either floor. The model has dimensions equivalent to those of each floor, along with having correct placement of windows and doors. The idea of linking to each floor is present not only in the full building model, but it is also present in the stairways of each floor. Since navigating up and down a staircase would indeed be a difficult task, cameras were placed in each stairwell and outside door. A menu of links was placed in each of the named places and the links were hooked to the cameras in the connecting area. This way, navigation up and down stairs is not necessary. One can simply change to a different floor file.

Once links between floors were established, links had to be set up for gathering information on rooms and objects. Links to HTML information pages on specific objects were set up to be obtained through the object containing the link. It was then set up that information on specific rooms and areas could be gathered through an icon floating in each room. The icon created was a yellow question mark approximately 1 meter high. This icon was selected because of its universal meaning. This visible symbol was placed in a direct line of sight from each entrance to a room. The icon is in every room and closet. Each question mark has a description field identifying either the room number of the room or a description such as "stairs." The icons are linked to separate pages each containing the room number or description, a link back to the 3-D floor, and possibly links to people or programs.

The information that the question marks link to was gathered from pamphlets on division projects, the World Wide Web, and input from local personnel. A message was sent out to each member of the division requesting information on themselves and their job. Some information was received and then organized. The information received was included in a description of the person. Everyone in the division had a description, even if they did not respond to the message. Information on the projects was obtained through a booklet on division projects. Local HTML files had previously been created that gave information on all of these projects. These files were revised to meet the style and content of the project. All of the pages on people and projects were linked based on who was involved in which projects.

Information was also gathered on things in the office such as printers, restrooms, and conference rooms. Generic layout pages were created for many of these items to show the possibilities of the project. For example, the conference room information page contains a listing for times the room is reserved. This listing was filled with random times, not actual reserved times. Other information pages, like the printer pages, contain actual information on the area being discussed. Links were established between information directories and these information pages. Along with the information pages on objects and areas, a directory listing all building 190 personnel, their phone and intercom numbers, and their room number was created. The phone directory is divided into divisions, and the HRGO personnel are linked to their personal description. Pages that go several layers deep were installed with "back" or "top" navigation buttons.

It was decided that these information and personal pages needed to be organized into a user friendly layout. The chosen layout was a framed page with a navigation banner on the top, a frame on the left side to display menus, and a main area to view information and three-dimensional worlds (*see Figure 1*). This layout allows the user to always return to the home page, or to switch to any main page, from any point in the program. All information pages, VRML worlds, and personnel pages were linked to the main page. Main topics were listed as hyperlinks in the navigation banner. Several simple home pages were created as starting off points for the program. They contain the links displayed in the banner and explanations of each topic. From the home or starting page, any of the other information pages or VRML worlds can be accessed.

Once the pages and worlds were completed and all the links were established, the program was tested. The links were all tested and the information presented was double-checked. Comments and suggestions from advisory personnel were entertained and modifications were made. The program was finalized at its current stage. Notes were made on possible expansions and improvements, along with method notes of what was completed, to aid in the on-going revisions necessary on a project of this type.

Discussion of Problems

During any project, one encounters problems and makes certain design decisions. In accordance with this fact, this project caused numerous obstacles. Unfortunately, solutions were not discovered for all of the known problems. Decisions had to be made to account for the unsolved problems and to fix the solved ones.

In today's high-speed, technological world quickness contributes greatly to an employer's decisions on which programs to use. No user would want a slow, tedious program to find information. In production of this project, speed definitely became a factor. In order to view three-dimensional worlds with realistic response times, one must use a Pentium computer. Even on a 486 computer with slightly less speed, a considerable difference in response time was noticed. In addition, the current Netscape version does not cache VRML worlds as it does HTML pages. Every time a user would want to revisit a previously loaded world, the entire world would have to be reloaded. No solution could be found to solve this caching dilemma in Netscape. Maintaining a basic structure with limited detail reduced the response time of the program. Upon completion of the building, animation was contemplated, however, this slows down the whole program. It was necessary to turn off the animation in order to move through the current VRML world, to another world, or to an HTML page.

In order to accommodate the computer memory size and software memory restrictions, one must limit the size of program files. At the beginning of this project, modelers were thought to add to the ease of production. However, these modelers eventually became cumbersome and produced large files. In the same way, textures added to the program created enormous files, also affecting the speed of the program. To accommodate for this problem with the textures, changing the image formats was a necessity. Therefore, the necessity of split files became apparent to solve this dilemma.

The large size of some of the files not only caused problems for the computer, but also for the authors of these files. This problem dictated the necessity of comments. Without multiple comments in each program segment, the finding of errors would be extremely difficult. Comments also eased the connection of the various files. It is to be hoped that the included comments will assist those who endeavor to edit the program segments in the future.

The visual aspects of VRML also produced problems in development of the three dimensional floors and building. When using cubes, one could see the seams where two cubes came together. No solution could be found to solve this problem, even after considerable time was spent in the effort to fix it. Another problem occurred when two faces from different figures were placed next to each other. The faces on one of the figures tended to show through the other side of the other figure. For example, in the three dimensional second floor, one can see a bookshelf showing through an office cubicle wall when "walking" down the hall. Once again, after trial, no solution was found. Even moving the objects away from the walls did not produce the intended results. Lastly, the visual effect called texture mapping also caused problems. One must piece a texture onto a flat cube or an indexed face before placement in the picture because textures cannot be placed on only certain portions of cubed walls. All of the textures that were placed in the worlds became distorted. Due to this deformity and a lack of good pictures to use as textures, the creation of textures became necessary. Because of the project developers' part in developing the textures, the pictures were easily edited to counter the distortion produced by the VRML viewer.

Results

As a result of this project, a basic office intranet was established. This intranet includes VRML models of the building and its floors, HTML information pages, and sample multimedia clips. The VRML worlds contain links to the HTML pages as well as HTML to VRML links. Some of the pages contain information on printers, conference rooms, building personnel, and division projects. The worlds and information currently available are meant to be revised and updated as changes occur. The pages and worlds that have been produced are meant to be a starting point for a finished office intranet.

As well as an office intranet, the project provided insight into using Web technologies in logistics efforts. One example is the development and presentation of electronic technical manuals for Air Force maintenance. Through HTML pages, maintenance technicians will be able to navigate electronic manuals more efficiently and effectively than the current paper manuals. Closely related to maintenance is Aircraft Battle Damage Assessment

and Repair (ABDAR). Using VRML to represent the aircraft's internal components, the assessment teams will be able to get an idea of what damage might exist without disassembling the aircraft. Another area of consideration is in the training field. The trainees can watch videos demonstrating their task, work with three-dimensional models with animation to practice, and read information on HTML pages. Lastly, VRML allows computerized representation of real world objects in a more realistic way. This more realistic representation will benefit the visualization of complex logistics processes by communicating a better understanding of these processes.

Further Developments

As in many cases, this project will never be truly done. Additions, revisions, up-dates, and advancements in techniques will always be necessary to keep it functioning at a productive level. Even before this series of work on the project was completed, room for expansion and improvement was noticed. Due partly to time, knowledge, and available technology, all possible aspects of the project were not included. Among the aspects not included are animation, scripting, forms, and multimedia.

Animation was not included in VRML worlds of this project because of current VRML specifications. The animation that is currently available slows down navigation in a world to an extent that makes the animation ineffective. This reduced response time is attributed to the fact that the computer must constantly return to the source to obtain the next series of animation. The ability to animate using programming languages was not a possibility because of the lack of experience of the project developers. While animation can be achieved in several ways, none of them currently met the needs of the project. With VRML 2.0, animation will be an established part of the language, hopefully allowing animation to be incorporated effectively into VRML worlds. Animation on HTML pages also slows usage, but is better established and can be incorporated more smoothly. As animation becomes more robust, it may be incorporated into this project and other efforts.

Imagemaps and text fields are two of the elements commonly seen on effective Web pages. Incorporating both imagemaps and forms into HTML documents requires a server, which was not available for this project. The ability to use CGI scripts would have allowed the inclusion of data pages that could be updated. An example use of

this element of HTML is a sign-in/sign-out board. Personnel in the division would be able to keep track of when coworkers are out of their offices. Another possible use of CGI scripting would be a reservation form for conference rooms, equipment, etc. Information could be kept current by using a "Submit Changes" form that would help maintain accurate HTML pages.

Multimedia is another element seen on popular web sites. Multimedia includes video clips, sound bites, and animation, among other things. Multimedia brings a vitality to the internet that was seen only before from CD-ROM applications. Multimedia links were included to demonstrate their possible usage in this project. Incorporation of multimedia data can further enhance the information visualization possibilities demonstrated through HTML and VRML.

This project was first undertaken from a building structure and utilities maintenance angle. When it was decided that many of the components that should be included in such an undertaking could be better presented through means other than VRML, the building and division information presentation position was adopted. Though the structural aspect of the building was somewhat ignored in VRML, room exists for including information on such things as computer networks, maintenance, electrical, sprinklers, and heating on HTML pages. Presenting this information along side a proportionate building model allows data to be displayed in a more effective format while maintaining a 3-D presentation. Along with presenting structural maintenance information, equipment information such as serial numbers and quantities could be included. If furniture and computer equipment were to be placed in each room, links could be created revealing ADPE identification numbers, serial numbers, and make and model information. All of this information could be included with the present information or used to establish a separate facility management information system.

Conclusion

This project was successful in fulfilling the objective. A start for an intranet and WWW home page was established. VRML files were created and linked to HTML pages. Information was gathered and presented in a

format not conventional to standard presentations. This use of a different approach brought a benefit to AL/HRG. Possible capabilities of HTML and VRML were investigated and shown to AL/HRG personnel. These uses may now be applied to existing and future logistic research efforts.

This project also helped to establish that at this time VRML is about presentation and appearance, not exactness or detail. This project was additionally successful in this aspect. The VRML files were kept small while maintaining a quality appearance. This same attribute was extended into the HTML pages. Along with being well displayed, all aspects of this project have been left open ended. This allows expansions and improvements to be made easily. The possibility exists to build onto what has already been accomplished. Creating a project in this way allows it to produce benefits in its current stage, as well as changes are made in technology.

The application of HTML and VRML did enhance the information displayed in this project. Without VRML and HTML it would not have been possible to effectively display a three-dimensional model of building 190 along side hypertext documents. This ability given to anyone through the World Wide Web should be put to use by AL/HRG in their logistics research programs. WWW technologies will benefit projects because of the user-friendly interface and realistic information display. The increasing enhancements being made to HTML and VRML will give them even more power as effective tools for multimedia presentations, models, displays, manuals, and training.

File   Edit   View   Go   Bookmarks   Options   Directory   Window   Help

Back   Forward   Home   Reload   Images   Open   Print   Find   Stop

Location: file:///a|/vrml/framehom.htm

What's New?   What's Cool?   Destinations   Net Search   People   Software

Building 190 - WPAFB, OHIO

BUILDING 190   FIRST FLOOR   SECOND FLOOR
DIRECTORY   PROJECTS   OTHER INFO   MAIN PAGE

Through this page you can...

View a 3D image of the building.

View 3D images of both floors.

See a directory of building 190 workers.

Read about the people working in the building.

Look at explanations of the various HRGO projects.

Access other information on the building and WPAFB.

walk   spin   look   slide   point   lamp   view   ?

Document: Done

Figure 1 - Screen capture showing frames and VRML

References

Matsuba, Stephen, and Bernie Roehl. Special Edition Using VRML. Indianapolis: Que Corporation, 1996.

Nadeau, David R., Andrea L. Ames, and John L. Moreland. "Optimizing the Performance of VRML Worlds." Dr. Dobb's Journal July 1996 : 16-24.

Netscape. Vers. 3.0b5aGold. Computer software. Netscape Communications Corporation, 1996.

Savola, Tom. Special Edition Using HTML. Indianapolis: Que Corporation, 1995.

The Virtual Reality Modeling Language Specification. World Wide Web Page, July 30 1996. Vers. 2.0, Final Working Draft, ISO/IEC WD 14772.

CREATING A LONGITUDE AND LATITUDE
PLOT USING SAS/GRAPH® SOFTWARE

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Final Report for:
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CREATING A LONGITUDE AND LATITUDE PLOT USING SAS/GRAPH SOFTWARE

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Abstract

This report details the methods used to create a graphic plot of certain longitude and latitude points on a United States map. Using the SAS System and SAS/GRAPH software, the approach detailed in this report: isolates the longitude and latitude coordinates in the original source data file, modifies the isolated data to fit the needs of the program, creates an annotate data set, combines the annotated data with a map data set, projects the collection of data and then separates the map and annotated data sets for output. The desired output is a map of the continental United States with an overlaid plot indicating longitude and latitude points.

CREATING A LONGITUDE AND LATITUDE PLOT USING SAS/GRAPH SOFTWARE

Andrew Binovi

Introduction

SAS/GRAPH software is the graphical component of the SAS System (SAS Institute 3). Using SAS data sets, SAS/GRAPH can create several types of graphs, including two and three dimensional plots, as well as charts and maps. The example outlined in this report uses the extensive mapping capabilities of the SAS/GRAPH software to create a map and an overlaying plot of certain longitude and latitude locations. This report uses the following steps to create the desired output:

1. Isolate and prepare the desired data from the source data file.

2. Prepare the annotate data set.

3. Prepare the map data for projection.

4. Combine and project the map data and the annotate data using the GPROJECT procedure.

5. Separate the projected annotate data from the projected map data using a data separation value.

6. Draw the annotated map using the GMAP procedure.

This example also demonstrates how to plot certain categories within the original data set. Using this example, all longitude and latitude coordinates could be plotted or only those coordinates meeting a certain condition could be plotted.

Methodology

SOURCE DATA AND VARIABLES

In the example illustrated in this report, the permanent data set MYLIB.ADDRESS is used. This data set contains a large amount of information concerning participants in a certain study. It contains 11166 observations and 19 variables. Of these 19 variables, only 4 are necessary to create the annotate data set. Table 1 describes the necessary variables:

TABLE 1

Name	Type	Description
ID	CHAR	Identification of study classification.
LATIT	NUM	Latitude of study participant expressed in decimal degrees.
LONGIT	NUM	Longitude of study participants expressed in decimal degrees.
STATE	NUM	The FIPS code of the state in which the study participant is located.

The longitude and latitude must fit the sign convention used in SAS map data sets. For the western hemisphere, above the equator (where most of the study participants are located), both north latitudes and west longitudes are positive. If the original data does not meet this sign convention, it must be changed to produce an accurate map. This will be discussed later in the report under the subheading *Converting Longitude and Latitude Data.*

TRIMMING THE SOURCE DATA SET

The unneeded variables in the source data set can be dropped. By trimming the excess variables before creating the annotate data set, the size of the data set can be greatly reduced. To create this trimmed data set, the SET statement is used to include

3-4

the source data set in the new data set, and the KEEP statement is used to declare which variables will be retained in the new data set.

```
/* Reduces the size of the data set to keep the variables */
/* ID, LONGIT, LATIT and STATE. */

libname mylib 'sas data-library';
data mylib.addtrim;
  set mylib.address;
  keep id longit latit state;
run;
```

This creates the new data set MYLIB.ADDTRIM containing only the essential variables needed to create the annotate data set. If only a certain condition of the ID variable is to be plotted, for example, only those study participants in the control group (ID="C"), then entering the following code after the KEEP statement will delete all observations not meeting that condition.

```
if id ne `C' then delete;
```

CREATING THE ANNOTATE DATA SET

The annotate data set can be created after the source data set is trimmed. To create the annotate data set ANNO1, the SET command must be used to include the ADDTRIM data set. Besides the variables from ADDTRIM, several other variables must be included in the annotate data set. A RETAIN statement is used to assign values to the variables essential to the annotation. The variable FUNCTION (which indicates the particular task of the annotate process, in this example the value is LABEL) must be included as well as the X and Y coordinates indicating where the task (defined by FUNCTION) will be executed. The X and Y variables must be accompanied by the XSYS

and YSYS variables. In this example, XSYS and YSYS are defined as 2, indicating X and Y are "absolute data values" (Malcom 58). WHEN indicates whether the annotation symbol is drawn before or after the procedure output. In the example, "a" signifies the annotation occurs after the map has been drawn. The POSITION value indicates where the value is drawn in relation to the X and Y coordinates. The value of "5" denotes the symbol or text is drawn at the center of the point indicated by X and Y. TEXT, STYLE, SIZE, and COLOR all refer to the output as it is viewed on screen.

```
/* RETAIN assigns values to all observations */
/* Defines essential variables to annotate data set */

data annol;
  set addtrim;
  length function style color $ 8 position $ 1 text $ 1;
  retain function 'label';
  xsys ysys '2';
  position '5';
  when 'a';
  style='swiss';
  size=0.35;
  color='black';
  text='*';
```

CONVERTING LONGITUDE AND LATITUDE DATA

Because of the nature the example, the longitude and latitude values will be used as X and Y. In the original source data set, and in the trimmed data set, LONGIT and LATIT are expressed in degrees. The SAS/GRAPH software expects map data to be expressed in radians. Therefore, the data must be converted to radians. This conversion is done within the annotate data set.

```
x=longit*arcos(-1)/180;
y=latit*arcos(-1)/180;
```

To convert the coordinates to meet the sign convention, a negative sign can be added before the variable LONGIT or LATIT, depending on which variable needs to be altered.

ASSIGNING DATA SEPARATION VALUES

The GPROJECT procedure will project both the map coordinates and the annotate coordinates to "ensure that the projection is the same for all coordinates and that the annotation is correctly positioned" (Malcom 59). The GMAP procedure, however, recognizes two separate data sets: one data set containing the map coordinates, and one data set containing the annotate data. The two sets must be separated after the GPROJECT procedure and before the GMAP procedure. In order to facilitate the separation, a data-separation value can be used. The map data contains the variable STATE, used as the ID variable during the GMAP procedure. If the value for STATE in the annotate data set is set well out of range of the map data, distinguishing between the two sets of data is simple. All observations where STATE=9999 is part of the annotate data set. All other observations, where STATE is within the proper range of the map data set, will be part of the map data set.

```
state=9999;
```

The process in which the data sets are combined and separated will be discussed later.

PREPARING THE MAP DATA FOR PROJECTION

The map data set must also be prepared. In this example, to facilitate the plotting process, all states and territories not part of the continental United States must be eliminated. The map data set will be trimmed, much like how the original source data was trimmed. On some systems, the SAS/GRAPH supplied map library may be in

a different location than the source data used for the longitude and latitude plots. It is advisable to check the host-information for the location of the SAS/GRAPH supplied map data.

```
/* Preparing the map data for projection */

libname maps 'sas-data-library';

data st48;
  set maps.states;
  id state ne 2 and state ne 15 and state ne 72;
run;
```

PROJECTING THE MAP

Before projecting the map and the annotate data sets, the two sets must be combined into one data set. This can easily be done with the SET command.

```
data combo;
  set st48 anno1;
run;
```

After the two data sets are combined, the combined data set can be projected onto the same set of axes using the GPROJECT procedure. The GPROJECT procedure includes several different options, including the type of projection and specification of the minimum and maximum longitude and latitude lines. In this example, a gnomonic projection will be used with the default longitude and latitude boundaries. The GPROJECT procedure will create an output data set called PROJ. The ID variable "identifies the variable in the input data set that defines unit areas" (SAS Institute 1162).

```
/* Projects the data set COMBO and produces the output data */
```

```
/* set PROJ. */

proc gproject data=combo
              out=proj
              project=gnomon;
   id state;
run;
```

DISPLAYING THE OUTPUT

Once the data has been combined and projected, the annotate data set must be separated from the map data set in order to run the GMAP procedure. This process involves the data-separation value defined in the original annotate data set. The annotate data containing the longitude and latitude values will be separated into the data set LONGP while the map data will be separated into the data set MAPP.

```
/* Separates projected data into two different data sets */

data longp mapp;
  if state=9999 then output longp;
                else output mapp;
run;
```

The GMAP procedure is run using MAPP as the MAP and the DATA values. The annotate data set becomes LONGP. The ID variable is STATE because the variable is common to both the data set used for the map and the annotate data set. A title is needed, but not a legend. Adding the option 'nolegend' deletes the default legend added with the GMAP procedure.

```
/* Creates a title for the output. */

title1 'Study Participant Locations';
```

```
/* GMAP procedure.  The option ALL indicates all states will be */
/* drawn, including those with no locations. */

proc gmap data=mapp map=mapp all;
  id state;
  choro state /nolegend
               annotate=longp;
run;
```

See Output 1 for complete output.

Results

Output 1

Study Participant Locations
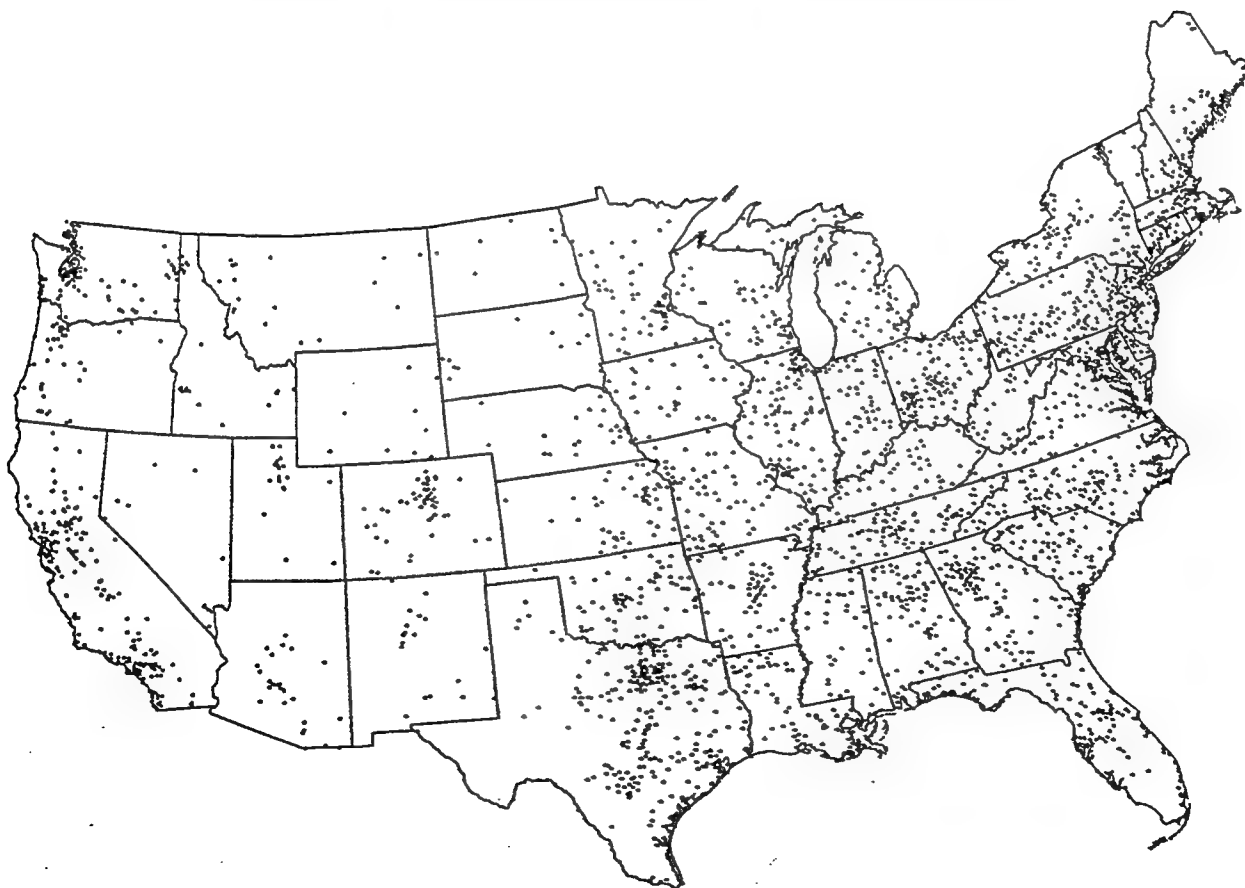
Conclusion

With a basic understanding of the SAS System and the SAS/GRAPH software, any user can use this program this program for a wide array of applications. In this example, the locations of the study participants is important in determining transportation costs to the test site. By examining the relative locations of those in the study, a better approximation of transportation costs can be reached. In other studies, geographical location becomes a factor when dealing with sun exposure or air pollution. Many uses can be found for the application of longitude and latitude data.

References

Malcom, Rooney H., and Malcom, Elizabeth N. "Annotating Maps with Data Symbols Using SAS/GRAPH Software." *Observations* Third Quarter 1994: 57-63.

SAS Institute Inc. *SAS/GRAPH Software: Reference, Version 6.* Vol. 2. Cary, NC: SAS Institute Inc., 1990. 2 vols.

Acknowledgment

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COMPLETE LISTING OF PROGRAM

```
/* Reduces the size of the data set to keep the variables */
/* ID, LONGIT, LATIT and STATE. */

libname mylib 'sas data-library';
data mylib.addtrim;
  set mylib.address;
 keep id longit latit state;
run;

/* RETAIN assigns values to all observations */
/* Defines essential variables to annotate data set */

data anno1;
  set addtrim;
  length function style color $ 8 position $ 1 text $ 1;
  retain function 'label';
  xsys ysys '2';
  position '5';
  when 'a';
  style='swiss';
  size=0.35;
  color='black';
  text='*';
  x=longit*arcos(-1)/180;
  y=latit*arcos(-1)/180;
  state=9999;
run;

/* Preparing the map data for projection */

libname maps 'sas-data-library';

data st48;
  set maps.states;
```

```
     id state ne 2 and state ne 15 and state ne 72;
run;


data combo;
  set st48 anno1;
run;


/* Projects the data set COMBO and produces the output data */
/* set PROJ. */


proc gproject data=combo
               out=proj
               project=gnomon;
  id state;
run;


/* Separates projected data into two different data sets */


data longp mapp;
  if state=9999 then output longp;
               else output mapp;
run;


/* Creates a title for the output. */


title1 'Study Participant Locations';


/* GMAP procedure.  The option ALL indicates all states will be */
/* drawn, including those with no locations. */


proc gmap data=mapp map=mapp all;
  id state;
  choro state /nolegend
               annotate=longp;
run;
```

THE EFFECT OF PROLONGED GROWTH ON A NON-SELECTIVE MEDIUM ON THE ABILITY OF *PSEUDOMONAS PSEUDOALCALIGENES* JS45 TO GROW ON NITROBENZENE

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THE EFFECT OF PROLONGED GROWTH ON A NON-SELECTIVE MEDIUM ON THE ABILITY OF *PSEUDOMONAS PSEUDOALCALIGENES* JS45 TO GROW ON NITROBENZENE

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Abstract

Experimentation was performed to determine if the ability of JS45 to grow on nitrobenzene is stable after prolonged growth on a non-selective medium. JS45 was grown in Mineral Salt's Broth and nitrobenzene, then transferred to a non-selective medium. Dilutions were plated on both non-selective agar and minimal agar with nitrobenzene vapor. This process was repeated several times. Experimental results indicated that the total number of JS45 cells and the number of cells that could grow on nitrobenzene were the same. Concluding that JS45 does not lose the ability to degrade nitrobenzene after prolonged growth on a non-selective medium. Therefore there is no permanent loss of nitrobenzene-degrading ability during non-selective growth, consequently scientists must find another mechanism to explain what causes the prolonged growth lag.

THE EFFECT OF PROLONGED GROWTH ON A NON-SELECTIVE MEDIUM ON THE ABILITY OF *PSEUDOMONAS PSEUDOALCALIGENES* JS45 TO GROW ON NITROBENZENE

Jennifer S Burnett

There has been much research in past years concerning JS45. It began with selecting *Pseudomonas pseudoalcaligenes* JS45 for growth on nitrobenzene. Then experimentation was done transferring JS45 from one culture of nitrobenzene to a second culture. The results from this experimentation showed no lag in growth when transferred. Additional experimentation was carried out transferring JS45 grown on succinate for 3 to 5 generations to a culture of nitrobenzene. The experimentation proved that when transferred in this way a 5 to 8 hour growth lag occurred. Finally, experimentation was performed allowing for JS45 to grow on succinate for a prolonged period of time then transferred to nitrobenzene. Under these conditions a 24 hour lag period was observed. The question addressed in the following research was: "Is the ability of JS45 to grow on nitrobenzene stable after prolonged growth on a non-selective medium?" To approach this question a culture of JS45 was grown on Minimal Salt's Broth and Nitrobenzene. A transfer was made to non-selective medium (Minimal Salts Broth and succinate). A serial dilution was made and plated on Minimal Salts Agar with nitrobenzene vapor and on non-selective agar (quarter strength Tryptic Soy Agar). These steps were then repeated several times. The colony counts on the non-selective agar represent the total number of bacteria present, therefore by comparing the colony counts of the non-selective agar with those of the Minimal Salts Agar and nitrobenzene vapor the percent of bacteria that retained the ability to grow on nitrobenzene can be calculated. Early data from experimentation seemed to indicate a loss of ability to grow on nitrobenzene. Because both large and small colonies were present a change was made extending the period before the colonies were counted. The later data proved the total number of cells, and the number of cells which could grow on nitrobenzene were the same. It can be concluded from the data that JS45 does not lose the ability to degrade nitrobenzene after prolonged growth on a non-selective medium. Since there is no permanent loss of nitrobenzene-degrading ability during non-selective growth, researchers must find some other mechanism to explain what causes the prolonged lag period.

REFERENCES

Nishino, S.F., and J. C. Spain. 1993. Degradation of nitrobenzene by a Pseudomonas pseudoalcaligenes. Applied and Environmental Microbiology **59**:2520-2525.

RECENT DEVELOPMENTS IN DOSIMETRY RESEARCH WITHIN AL/OER

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Final Report for:
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Abstract

The process of converting the contents of the <u>Radiofrequency Radiation Dosimetry Handbook</u> into a digital format to be put onto the World Wide Web (WWW) was initiated. This process involved the use of Microsoft Word, Web Author, and Netscape software. The problem of converting mathematical symbols and Greek letters was over come by the use of Adobe PhotoShop to make an image that was placed into the text. In addition to making WWW pages, I worked on creating a mathematical model of a Phantom Monkey. This process involved using axial magnetic resonance imaging scans of the phantom. The scans where color coded to represent body mass and external air. These coded images were assembled to make a 3-dimensional reconstructed image of the real Phantom Monkey. This mathematical model of the phantom will increase the speed and reduce the cost of dosimetery research within AL/OER.

Dosimetry Handbook

The Radiofrequency Radiation Dosimetry Handbook (Durney et al, 1986) is a manual for researchers to use as a reference for the dosimetry of nonionizing radiation. Hard copies where made initially and distributed upon request. As the number of books in stock dwindled over the past 10 years and with the approach of designing the next edition of the handbook a decision was made to put the handbook into a digital format and place it on the World Wide Web (WWW) for quick access, ease of distribution, and as a more economical approach. Through training, experimentation and implementation, this process has been the primary component of my research this summer. This task involved scanning all 540 pages of the manual into bitmap digital pictures and then sending them through an optical character reader to be converted into a text format. This was done using Paper Port software that was linked to Microsoft Word and Adobe PhotoShop software on a Pentium 90 processor. A software plug-in for Microsoft Word is Web Author (Quarterdeck Corp.), which changes text files into Hypertext Markup Language (HTML) (see Figure 1) format so that they can be read by a HTML browser, such as Netscape (see Figure 2), on the Internet.

One of the problems encountered is that HTML does not support some Greek letters and mathematical symbols. To solve this problem all equations, diagrams, and most symbols had to be made into an image that was placed into the text. This was done using PhotoShop software. In PhotoShop, these images were cropped rotated, moved, and then converted into a JPEG format. JPEG is an image format that compresses files that appear on the Web. This compression reduces the amount of time required to download an image into a WWW browser. Images within a sentence were formatted to be consistent in size with the surrounding text characters. Images placed between paragraphs were centered to provide a smooth, organized appearance to the page. The next step on this project, which will be continued after I leave this summer AFOSR sponsored program, will be to combine all the individual pages for each chapter into a single file. This increases the efficiency which a network browser can view any selected chapter. In addition, a search engine will be produced to permit the localization of particular text based on the key words selected. Projected additions include incorporating JAVA script to permit

user interactions with the data. The user could obtain specific absorption rates (SAR) by providing the desired frequency, power density, and object orientation with respect to the transmitter.

The past four hard copy versions of the Dosimetry Handbook have been one of the most popular products of the AL/OER division. Furthermore, the Dosimetry Handbook is one of the most cited publication within the electromagnetic field community. This new digital format will further increase the popularity and usefulness of the Dosimetry Handbook.

<u>Dosimetry Phantoms</u>

To predict the amount of energy absorbed by animals or humans exposed to electromagnetic fields, the present methodology includes placing temperatures probes in a human, animal or in a phantom that represents the human or animal. This process is very slow and tedious since 1/4 inch resolution is often desired. This resolution is required at higher frequencies (>1GHz) due to the short wavelength.

To obtain SAR values at a variety of exposure parameters, the AL/OER division has begun using mathematical codes, such as the Finite Difference-Time Domain (FD-TD) code. This process reduces the number of man-hours and live subjects required to obtain the necessary data. Input to the FD-TD model consists of data representing the accurate anatomical structure of each subject. These data were obtained from magnetic resonance imaging (MRI) scans of the Rhesus Monkey-Phantom that was made from a canvas-like material filled with a saline-based solution. I was involved in making a computer model of the phantom. To make the computer model, the 338 original MRI scans of the phantom in a sitting position and 320 images of the phantom in a squatting position were color coded to differentiate external air from body mass. To check for correct alignment in the X, Y, and Z planes, images were reconstructed 3-dimensionally using Slicer software (SpyGlass, Inc.). Once coded the digital information contained within each image is incorporated into the FD-TD code. To validate this code, the SAR values will be compared to those obtained from actual exposures. In summary I have learned about what research is being done in the Air Force and particularly, in the AL/OER division. While working in the AL/OER division I saw a large amount of physics within the research being done, of which I have an interest in pursuing.

FIGURE CAPTIONS

FIGURE 1: HTML-coded page for the cover of the Dosimetry Handbook.

FIGURE 2: HTML-coded page for the cover of the Dosimetry Handbook as it appears when viewing with a NetScape browser.

REFERENCES

Durney, C.H., Massoudi, H., and Iskander, M.F. Radiofrequency Radiation Dosimetry Handbook, 4[th]ed., USAFSAM-TR-85-73, Brooks Air Force Base, TX, 1986.

A STUDY OF THE INFLUENCE OF RELATIVE LOADS AND G-FORCES ON
ELECTROMYOGRAPHIC ACTIVITY

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A STUDY OF THE INFLUENCE OF RELATIVE LOADS AND G-FORCES ON ELECTROMYOGRAPHIC ACTIVITY

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Abstract

In this study, electromyography was used to measure the voltages of four muscles in the neck area: the left sternocleidomastoid, right sternocleidomastoid, left trapezius, and right trapezius. The purpose of this study was to predict the presence of an extra weight in a helmet (a "loaded" helmet) by analyzing EMG data, and to compare the levels of EMG activity at varying gravitational forces. A human centrifuge carried subjects up to 9 G. Statistical analysis found significantly greater muscle activity at higher G levels, but a reliable method for predicting a loaded helmet was not achieved.

A STUDY OF THE INFLUENCE OF RELATIVE LOADS AND G-FORCES ON ELECTROMYOGRAPHIC ACTIVITY

Lenis Chen

Introduction/Discussion of Problem

While flying, pilots experience substantial gravitational (G) forces as they change direction and position. The Dynamic Environment Simulator (DES) rotates at speeds that create G forces similar to those encountered in flight. The physiological changes of subjects under such forces may therefore be measured under the more controlled conditions of the DES. Two aims of this study were to analyze the effects of varying G forces on several muscles using electromyography and to predict the presence of a loaded helmet by comparing the EMG data for a loaded helmet with the data for an unloaded helmet. This type of study has ergonomic applications to flight. Literature on similar topics has been written concerning the application of EMG to ergonomics. Jonsson [1] describes several applications of EMG to ergonomics, namely, the measure of muscle fatigue, muscle coordination studies, quantitative electromyography, and qualitative electromyography. In addition, Jonsson [1] remarks that in the area of quantitative electromyography, the measurements of absolute or relative loads on individual muscles have been of interest. This study involves a quantitative analysis of data in order to compare and evaluate the effects of relative loads on four muscles. P. Vestergaard-Poulsen, et al. [2] investigates the use of EMG along with ^{31}P nuclear magnetic resonance spectroscopy to measure muscle metabolism as well as physical muscle activity. Baidya and Stevenson [3] study muscle fatigue in work involving repetition. Lamb and Hobart [4] explain how EMG works by describing the relationship between muscle activity and voltage. In muscle, the stimulation of a muscle fiber in one area quickly leads to the propagation of an action potential in other regions of the fiber, often in more than one direction [4]. Muscle activity causes a change in electrical potential to travel along a muscle fiber; this difference in electrical potential can be measured through surface electromyography [4]. Therefore, a difference in electrical potential signifies muscle activity; absence of such a difference indicates a rest period [4].

Methodology

Subjects

Six male and female Air Force members participated as subjects in this study.

Equipment

Silver/silver chloride surface electrodes were applied in a bipolar configuration to four muscles in the neck and shoulder area. These muscles were the left sternocleidomastoid (L SCM), the right sternocleidomastoid (R SCM), the left trapezius (L Tz), and the right trapezius (R Tz). The four muscles were close to the surface of the body and were not directly blocked by any surrounding muscles. Gary L.

Soderberg {5} included surface electrodes as one of the most applicable and practical types of electrodes. Two electrodes recorded the muscle activity of each muscle, and a ground electrode served as a reference for each pair of electrodes. The placement of the ground electrode in an electrically neutral area allowed for a difference in electrical potential between each electrode and the ground electrode; the responses between these differences were compared to produce an amount of muscle activity {5}. Wires connected to the surface electrodes lead down to a belt worn by the subject. A telemetry system enabled the transmittal of signals from the subject to an antenna. One of the advantages of using a telemetry system, as suggested by Gerleman and Cook {6}, was that the cables used in EMG collection would not greatly limit the degree of movement or degree of freedom of the subject; the telemetry system allowed greater distance between the subject and the person collecting the data. This advantage was useful due to the necessary collection of data outside the centrifuge area.

Experiment

Subjects sat in a centrifuge and rotated at speeds producing varying G-forces. Subjects wore helmets in all runs. Data collection ran at 200 Hz to a digital recorder, and a computer stored the data. Most subjects participated in two sets of runs, each set consisting of four runs each. One set of runs is displayed in Figure 1. A run could be defined as an uninterrupted period of time in which the subject rotated at increasingly faster speeds, from 1 G to 9 G, and then continued to rotate at slower speeds until the centrifuge reached 1 G. Except for one run, all runs within one set took place on the same day in the same sitting. Between each run, subjects had a rest period of about two minutes. The rest period was flexible in that subjects who were ready for another run could begin again before their two-minute period had ended. The first two runs of a set were labeled "test 1," while the second two runs were "test 2." Subjects did not leave their seats in between tests. Of the two runs in each test, one required relatively less time to climb from 1 G to 9 G; this run was labeled "rapid." Each rapid run lasted approximately 30 seconds. Runs that required relatively more time were labeled "gradual." Hence, each set of four runs consisted of two tests, and each test consisted of one rapid and one gradual run. In any particular test, the order in which the runs took place was entirely random. Therefore, the chances of a subject undergoing a gradual run and then a rapid run were the same as those chances of undergoing a rapid and then a gradual run. Tests in which the subjects did and did not have extra weight in their helmets were labeled "loaded" and "unloaded," respectively. One of the two tests, test 1 or test 2, was loaded in each set of runs. Our task was to predict which test was loaded--that is, which test was run with a weighted helmet. The order in which tests were loaded or unloaded was also determined randomly.

Analytical Procedure

At 200 Hz, the computer had a capacity to store three blocks of data, each block consisting of approximately 6,000 points of data. However, only the first of three blocks was accessible through the computer. Since the rapid runs took relatively less time, all the rapid run data could be accessed, but not all

the data from gradual runs was available for use. Only analysis of data relating to approximately 3-5 G was available for the gradual runs. For all runs, only some data from 1 G to 9 G (not 9 G back down to 1 G) underwent statistical analysis. The resulting digital data was converted into volts by the formula Volts = (A*20.0/4096)-10, where A is any number in digital format. The absolute values of these voltage values were taken. For both rapid and gradual runs, data analysis consisted of statistical analysis of a 200-point group of data. Through the analysis of this voltage data, the effects of the relative loads on each subject could be compared to see if a prediction of the loaded helmet was possible. The mean voltage and standard deviation of the 200 points were calculated for each of the four muscles. The averages of two runs from two tests, one test loaded and the other unloaded, were placed together for comparison. A student's t-test was used to determine if a significant difference existed between the average values of the two tests. A value of less than .05 resulting from the t-test represented a significant difference between the two values. Provided that a significant difference existed, the test with the higher average was noted. A tally of the number of test 1 averages that were greater than the test 2 averages or vice versa provided a method for predicting which tests were run with the loaded helmet.

FILENAME	PROFILE
19AP96A	GRADUAL
19AP96B	RAPID
19AP96C	GRADUAL
19AP96D	RAPID

Figure 1. One set of runs. The names of the runs reflect the days on which they took place. Each name also includes a letter identification (i.e., A, B, C, D). The first two runs, 19AP96A and 19AP96B, combine to form one test, while 19AP96C and 19AP96D together form another test. One of the two tests is loaded.

Results

Helmet Load Predictions

In total, thirteen predictions were made concerning which test was considered loaded, test 1 or test 2. Figure 2 displays the results of such predictions. The titles of each pair of runs are on the left-most column. Two runs, one from test 1 and the other from test 2, form the title for one row. For example, 19AP96AC involves two gradual runs: one from test 1 (19AP96A) and one from test 2 (19AP96C). One of these tests was taken with the loaded helmet. Through the comparison of mean voltage values for two runs--for instance, 19AP96A and 19AP96C--the test that appeared to show more muscle activity and thus more weight in the helmet was recorded. A "1" in a column indicates that test 1 appeared to show more muscle activity through the comparison of mean values. A "2" in a column indicates that test 2 appeared to show more muscle activity. A "?" means that tests 1 and 2 were equally represented. "N/S" means a significant difference did not exist between two sets of data, so a judgment could not be made concerning which test involved the loaded helmet. The columns in Figure 2 following the titles of the runs display the

predictions of which tests are loaded. The column labeled "Predict Rap 3 G" is the prediction of which test is loaded based upon only the 3 G information in the rapid runs. Similarly, "Predict 8 G" is the prediction of which test is loaded based upon only the 8 G information in the rapid runs. The results in the information from these two columns combined, both 3 G and 8 G, are displayed under the "Predict Rapids" column. The "Predict Grad" column contains predictions based solely upon the information gathered from gradual runs. Finally, the "Predict Total" column considers rapid and gradual runs and involves both the 3 G and 8 G data from the rapid runs. The actual results are represented in the next column. The number of correct predictions is displayed as a percentage at the bottom of the second page of Figure 2. Percentages correspond to their respective columns and therefore differ according to prediction method. The overall prediction, the prediction based on a total combination of rapid and gradual runs, indicates a match 46% of the time; six of the thirteen predictions were correct and matched with the actual results. William Marras {7} wrote that the purpose of statistical comparisons was partly to rule out chance. In the study of loaded versus unloaded helmets, results from statistical comparisons were very similar to those that may have resulted from chance. All the prediction methods revealed an accuracy of around 50%. The low percentage resulting from the total prediction was contrary to expectation, and the other low percentages illustrated this problem as well. A few of the runs must be considered potentially inaccurate due to the data collection process. For instance, subject #2 did not have four runs on the same day; instead, she made up a missed run on a different day. As Soderberg notes {5}, reliability is greater if measurements are taken the same day. Therefore, the problem of inter-day variability must be considered for the gradual run of subject #2. Also, not all the data was collected for some runs of subject #3. Not all the incorrect predictions appeared to stem from such causes, however. In the case of subject #1, all predictions for the set of runs titled 25AP96IK and 25AP96JL supported test 2 as the test with the loaded helmet. The actual loaded helmet in test 1 proved otherwise.

To determine if these low percentages resulted from the data selected and analyzed, wider ranges were selected for some data to see if the statistical analysis would yield different results. These results are displayed in the last two columns of Figure 2. The first column, labeled "Predict Ext.," predicts which tests are heavier based on only gradual or only rapid runs. The predictions that are based on gradual runs are in the same row as the titles with gradual runs; the same is true for rapid runs. The column titled "Predict Ex. Tot." gives the total prediction based on both gradual and rapid runs. Both of these columns involve the extended data only. A comparison between extended predictions and actual loads revealed much discrepancy between predictions and results. However, a comparison of only the gradual extended results with the actual results showed that a number of predictions did match with the actual results. Not all predictions agreed, though, and a greater sampling size is needed to determine if the gradual extended method was any better than previously used methods.

An additional attempt to predict loaded helmets consisted of analyzing data near the peak of each run, at times when gravitational forces were estimated to be highest. This information could only be accessed in the rapid runs. Data from the peak of each run was collected approximately 17 to 20 seconds into each run. The data corresponding to expected peak values was analyzed by using mean values and t-tests to determine if the correct helmet could be predicted. A majority of predictions using this method were incorrect.

Effects of G-forces

Another purpose of this study was to quantitatively analyze the effects of varying G-forces on EMG activity. Similar to the analytical method used with loaded and unloaded helmets, the method used to analyze the effects of G-forces also included the determination of mean values and the use of a student's t-test. Note must be made that when comparing loaded and unloaded helmets, the G-level remained constant. The presence or absence of a load was likewise held constant when the effects of G-forces were compared. Excluding the ambiguous data of one of the subjects, approximately 66.667% of data favored muscle activity being higher at 8 G as opposed to 3 G. Approximately 11.458% of data favored muscle activity being higher at 3 G. The remaining data, which comprised approximately 21.875% of the total, was non-significant. These results were closer to expectation than were the results concerning variable helmet loads. The relatively high percentage in favor of greater EMG activity at 8 G suggested that the comparison of voltage levels for this purpose was successful to some extent. The results from this G-force comparison could be more favorable because the comparison was made within a test instead of between two tests. More variability could come into play when comparing muscle activity of different tests.

Signal quality

In an additional run, an oscillator that replaced the surface electrodes was connected to the belt pack of one subject. This oscillator sent out a constant signal regardless of the G-level. A line graph of the data is shown in Figure 3. The overall shape of this graph satisfied expectation, since not many deviations from the straight shape are apparent. Also, the shape of the graph suggested that the signal quality did not become greatly distorted as the signal traveled from the subject to the computer collecting the EMG data. However, periodic oscillations at the bottom of the graph suggested aliasing. By graphing the oscillator activity without centrifuge rotation, it was determined that the centrifuge movement did not contribute to the periodic curves and that the cause was probably aliasing.

Graphs of data

Since the centrifuge rotated at faster and faster speeds from 1 G up to 9 G, and since the centrifuge rotated at increasingly slower speeds in its return to 1 G, the graph of any run was expected to provide some sort of bell-curved shape. This shape would indicate an increase in muscle activity as the centrifuge rotated faster, and a decrease in voltage as the centrifuge descended to lower G-force levels. The line graphs of two runs for subject #1, with four muscle measurements per run, are shown in Figures 4 and 5.

Figure 4 shows a rapid run from test 1, while Figure 5 shows a rapid run from test 2. The horizontal axis represents time with respect to data collection frequency; 200 points of data correspond to a second, so the 6000 points displayed correspond to a 30-second rapid run. With a few exceptions, voltage ranges displayed in the graphs are the same for muscles of the same type to allow comparison among the graphs. For example, the graph of the right sternocleidomastoid muscle has the same range in both Figures 4 and 5, even though some values for the muscle are cut off in Figure 5. Of the four muscles surveyed, the right sternocleidomastoid most clearly assumed a bell shape; also, this muscle appeared to show more activity in test 2 than in test 1. The R SCM had the most significant difference out of all four muscles when a t-test was used to compare test 1 with test 2. In fact, test 2 did indeed contain the loaded helmet. A large significant difference also existed in comparing data corresponding with 3 G to that of 8 G. The bell shape of both R SCM curves in figures 4 and 5 met expectations that muscle activity at 3 G (at an x-value of approximately 600-800, or 3-4 seconds) would be less than muscle activity at 8 G (at an x-value of approximately 2400-2600, or 12-13 seconds). In using the student's t-test for comparison of 3 G v. 8 G data in the left trapezius, no significant difference of $p < .05$ was found. The corresponding graphs supported this quantitative finding, since both L Tz graphs were relatively flat and did not assume a distinct bell-like shape. In this particular case, the findings concerning the amount of bell-shaped curvature, the degree of significant difference, and the accuracy of prediction suggested a possible correlation between the graph of a muscle's activity and the reliability of a prediction in helmet load. In examining some graphs, a comparison of graphs between two tests did not always reveal a clear-cut favor for one test over another. For example, figures 6 and 7 show graphs of subject #5 that did not distinctly indicate that either test 1 or test 2 contained the loaded helmet. In actuality, test 1, the graphs of figure 6, were the graphs of a subject wearing a loaded helmet. The R SCM graph in figure 6 contained spike-like projections, apart from the main shape of the graph, that formed a bell shape. These spikes were not found in all graphs, although spikes similar to those in figures 6 and 7 were found in figures 4 and 5 in the R SCM graph. The cause of these somewhat periodic spikes was unknown but could be attributed to what Glaser, Ezenwa, and Popper {8} have studied, which is referred to as an AGSM. AGSM stands for Anti-G Straining Maneuver, and pilots have used this straining maneuver under high G-levels {8}. Glaser, Ezenwa, and Popper {8} have written of electromyography used with arm, leg, and abdominal muscles that were involved in a type of AGSM. A possibility exists that the trapezius or sternocleidomastoid muscles may also be affected by this type of maneuver. Vitti, et al. {9} have found moderate activity in the sternocleidomastoid muscles during deep breathing, and they believe that the muscle is an auxiliary muscle used in deep breathing. This reasoning would not only explain the presence of spikes in the graphs but also may explain the inaccuracy of helmet load predictions. Further studies in this area would be necessary to determine any correlation between straining maneuvers and EMG activity, as well as the impact of such straining maneuvers on helmet load predictions. Other movements were made by subjects in response to higher gravitational

6-8

forces. At 4 G, subjects were instructed to pull their heads back in preparation for the higher G-forces. This movement was expected to produce a peak in the graphs because of the muscle activity involved. However, in general, no specific peak was found to correspond with such a movement in the graphs.

A Note about MVC

Questions may be posed concerning the use of Maximum Voluntary Contractions (MVC). Attempts were made to see the effects of an MVC with one subject. Most of the time, the subject pulled her head back as hard as she could, with the aim of producing a high degree of muscle activity. However, a comparison of mean MVC values with mean values taken during a rapid run showed that the MVC values were smaller than many of the rapid run values. This could mean that the subject did not exert enough strength for a maximum voluntary contraction or that such a voluntary contraction was not appropriate for runs dealing with mainly involuntary muscle activity. Such results could also mean that the values obtained in the runs were necessarily higher due to the increased G forces. Figure 8 illustrates the discrepancy between the MVC values and the rapid run values. Graphs of the MVC in the R Tz were relatively flat, so R Tz values in Figure 8 do not reflect a maximum voluntary contraction. MVC graphs of other muscles appeared satisfactory. In figure 8, the values given at the end of each title are the x-values of time that were chosen; these values were estimated by looking at MVC line graphs. The mean values of the very first MVC taken were those of the initial MVC. The initial MVC was taken at the beginning of one test, while the intermediate MVC was taken right after that test. The final MVC was taken after two tests were completed. The mean values of the initial MVC were all lower than the average values for a rapid run taken at both 3 G and 8 G. A comparison of the intermediate MVC values with the initial MVC showed that the intermediate values were higher. These values represented the amplitude values of an EMG signal. Such authors as Redfern {10} and Jonsson {1} acknowledged a decrease in EMG frequency but an increase in amplitude under conditions of muscle fatigue. The increased intermediate MVC values could have been a sign of muscle fatigue. Just as Hagberg and Sundelin {11} did not use frequency analysis in their study, so too was such a technique not used to determine the presence of muscle fatigue in this study. If such fatigue did exist, a longer rest period between runs would be necessary. In comparing the 3 G values of the rapid run with those corresponding to 8 G, most of the 8 G values were higher than the 3 G values, which confirmed expectation. As Jonsson had noted, normalization may not always be necessary in quantitative studies, particularly if relative muscle loads were quantitatively analyzed to determine which work situation corresponded with a higher muscular load {1}. Often, concerns about comparing different muscles or comparing data across individuals have required the use of normalization procedures. These factors were not of concern in the present EMG study since only the same types of muscles were compared, and since direct comparisons between different individuals did not exist.

Conclusion

In conclusion, the differences in helmet load could not be satisfactorily predicted with the quantitative analysis of EMG data. A significant difference was seen, however, between EMG data at 3 G and EMG data at 8 G. Possible causes for the inability to predict helmet load included the use of straining maneuvers during the runs, sample size, and the process of data collection or data analysis. Another concern of this study was to determine the reliability of EMG itself. This study posed questions about such reliability in EMG in general and in certain methods of analyzing EMG. The lack of a definite bell shape in the graphs could be attributed to technical difficulties associated with the EMG collection, aliasing, or frequency of data collection. The absence of techniques such as root mean square or integration could also have affected results. The RMS or integration techniques were not available for use in this study but remain a possibility for different studies once the proper software is obtained. A possibility existed that the actual impact of helmet load on the sternocleidomastoid and trapezius muscles was, on the whole, not significant. However, when a subject was asked if she could feel a difference between the loaded and unloaded helmets, she replied that she could. Also, the weight of the additional load at 1 G was two pounds. At 9 G, the load should have been perceived as a heavy 18 pounds, which was why muscle activity was expected to increase at high G. The comparison of mean values used in predictions of helmet load may have been influenced by outliers caused perhaps by the straining maneuver. In this study, predictions were made based on both gradual and rapid runs. However, the amount of rapid data available was twice that of the gradual data available due to the limited accessibility of gradual data within a certain G-level range. Access to higher G levels for the gradual runs may have altered results gathered thus far.

This experiment could be modified in the future to gain useful information about the impact of helmets on pilots. A normalization procedure may enable further studies in which not only helmet loads could be detected, but also the degree of influence of helmet loads on certain muscles could be measured. The straining maneuver may also be monitored for the neck and shoulder muscles to see if they are adversely affected. One method for determining if the straining maneuver affects such muscles would be to time the strains of a subject and correspond those times to a graph of the subject's run. Such strains might show up on the graphs as regular peaks. Also, arm, leg, and abdominal muscles under AGSM have been studied by Glaser, Ezenwa, and Popper {8} for muscle fatigue. Such studies of fatigue may also be studied in the neck muscles. Some subjects have ridden on the centrifuge without any helmets at all; the effects of such an absence of a helmet may lead to interesting results concerning the stress placed on certain muscles. This experiment could also be expanded to test different kinds of helmets in the search for a helmet that would result in the least muscle strain.

6-10

References

1.) Jonsson, Bengt. "Electromyography in Ergonomics." *Electromyographical Kinesiology.* Eds. P. A. Anderson, D. J. Hobart, and J. V. Danoff. 1991, 133-36.

2.) Vestergaard-Poulsen, P., C. Thomsen, T. Sinkjaer, M. Stubgaard, A. Rosenfalck, and O. Henriksen. "Simultaneous electromyography and ^{31}P nuclear magnetic resonance spectroscopy--with application to muscle fatigue." *Electroenceph. clin. Neurophysiol.*, 1992, **85**: 402-11.

3.) Baidya, K. N., and M. G. Stevenson. "Local muscle fatigue in repetitive work." *Ergonomics*, 1988, **31**: 227-39.

4.) Lamb, Robert, and Donald Hobart. "Anatomic and Physiologic Basis for Surface Electromyography." *In: Selected Topics in Surface Electromyography for use in the Occupational Setting: Expert Perspectives.* U.S. Department of Health and Human Services, 1992. 5-22.

5.) Soderberg, Gary L. "Recording Techniques." *In: Selected Topics in Surface Electromyography for use in the Occupational Setting: Expert Perspectives.* U.S. Department of Health and Human Services, 1992. 23-41.

6.) Gerleman, David G., and Thomas M. Cook. "Instrumentation." *In: Selected Topics in Surface Electromyography for use in the Occupational Setting: Expert Perspectives.* U.S. Department of Health and Human Services, 1992. 43-68.

7.) Marras, William. "Applications of Electromyography in Ergonomics." *In: Selected Topics in Surface Electromyography for use in the Occupational Setting: Expert Perspectives.* U.S. Department of Health and Human Services, 1992. 121-43.

8.) Glaser, Roger M., Bertram Ezenwa, and Stephen E. Popper. "Physiologic Evaluation of the L1/M1 Anti-G Straining Maneuver." *AAMRL-TR-90-083*, 1990.

9.) Vitti, Mathias, Makoto Fujiwara, John V. Basmajian, and Masaru Iida. "The Integrated Roles of Longus Colli and Sternocleidomastoid Muscles: An Electromyographic Study." *Anat. Rec.*, 1973, **177**: 471-484.

10.) Redfern, Mark. "Functional Muscle: Effects on Electromyographic Output." *In: Selected Topics in Surface Electromyography for use in the Occupational Setting: Expert Perspectives.* U.S. Department of Health and Human Services, 1992. 103-120.

11.) Hagberg, Mats, and Gunnevi Sundelin. "Discomfort and load on the upper trapezius muscle when operating a wordprocessor." *Ergonomics*, 1986, **29**: 1637-45.

Figure 2: Predictions and Actual Results

	PREDICT RAP 3G	PREDICT RAP 8G	PREDICT RAPIDS	PREDICT GRAD	PREDICT TOTAL	ACTUAL	PREDICT EXT.	PREDICT EX. TOT.
Subject #1								
19AP96AC Gradual	2	2	2	1	2	2		
19AP96BD Rapid								
23AP96JL Rapid	?	2	2	2	2	2	1	1
23AP96KM Gradual							2	
25AP96IK Gradual	2	2	2	2	2	1		
25AP96JL Rapid								
Subject #2								
23AP96AC Rapid	2	1	1 ?		1	2	1	1
23AP96BQ* Gradual							2	
26AP96MP Gradual	1	2 ?		1	1	1	1	2
26AP96NO Rapid							2	
Subject #3								
23AP96FH Rapid	?	2	2	2	2	1		
23AP96GI Gradual								
26AP96AC Rapid	2	2	2	1	2	2		
26AP96BD Gradual								
Subject #4								
24AP96AC Gradual	1	2	2	1	2	2	1	
24AP96BD Rapid								
26AP96IL Gradual	1	2	2	1 ?	1	1		
26AP96JK Rapid								

Figure 2: Predictions and Actual Results

	PREDICT RAP 3G	PREDICT RAP 8G	PREDICT RAPIDS	PREDICT GRADUA	PREDICT TOTAL	ACTUAL	PREDICT EXT.	PREDICT EX. TOT.
Subject #5								
24AP96EG Rapid	2	2	2	1	2	1	2	2
24AP96FH Gradual							1	
26AP96SV Rapid	1	1	1	2?	2?	2		
26AP96TU Gradual								
Subject #6								
25AP96EH Rapid	1	1	1	2	1	2		
25AP96FG Gradual							1	
26AP96EH Rapid	1	1	1	1	1	1	1	
26AP96FG Gradual								
	6/13 COR	5/13 COR	5/13 COR	7/13 COR	6/13 CORRECT			
	46.15%	38.46%	38.46%	53.85%	46.15%			

Figure 3

Oscillator Graph
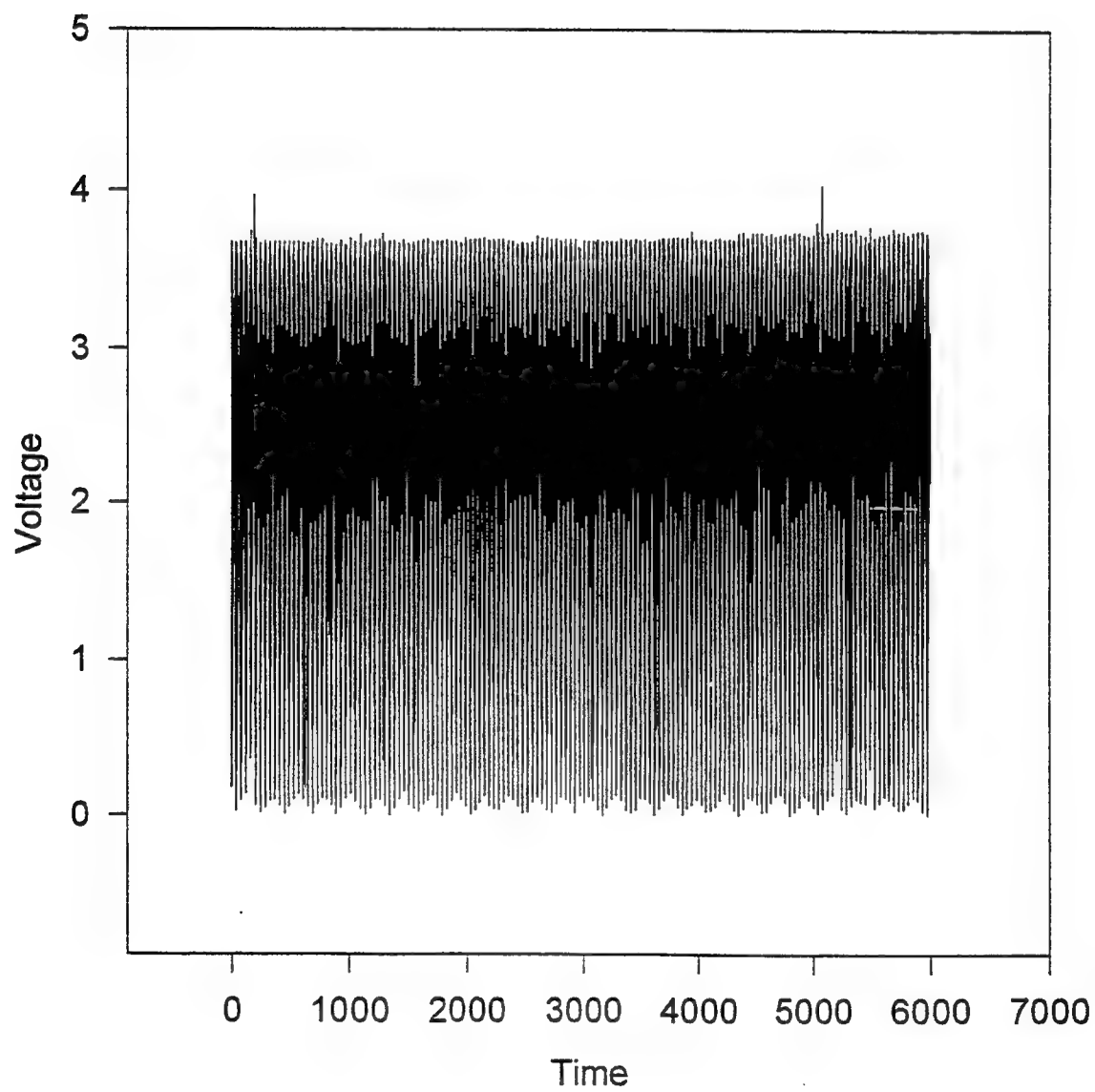
Figure 4

L SCM

R SCM

L Tz

R Tz

6-15

Figure 5

L SCM

R SCM

L Tz

R Tz

6-16
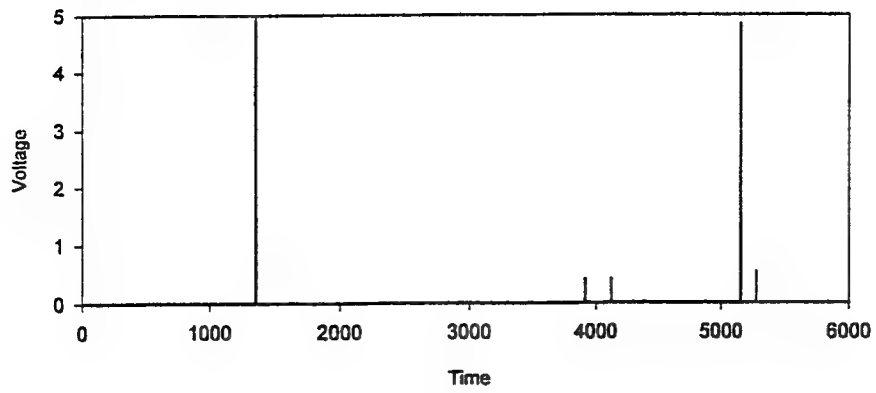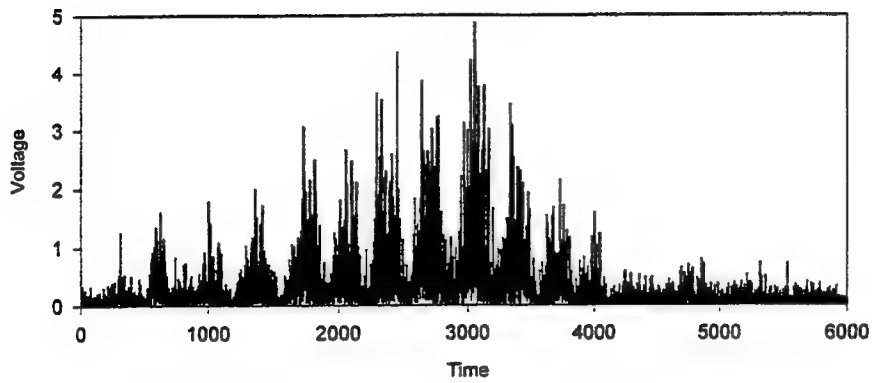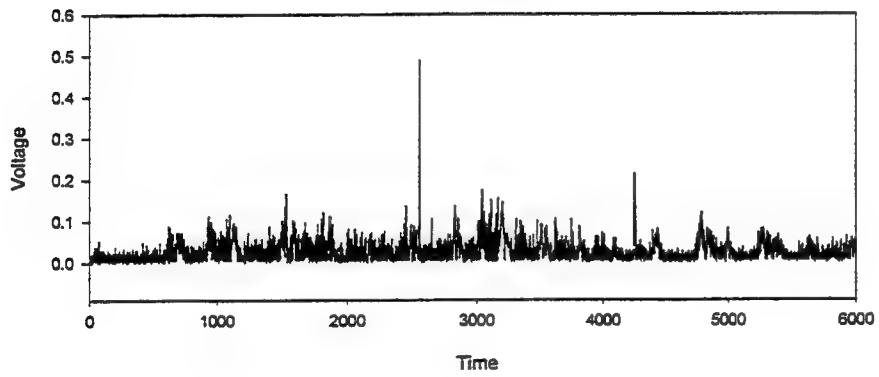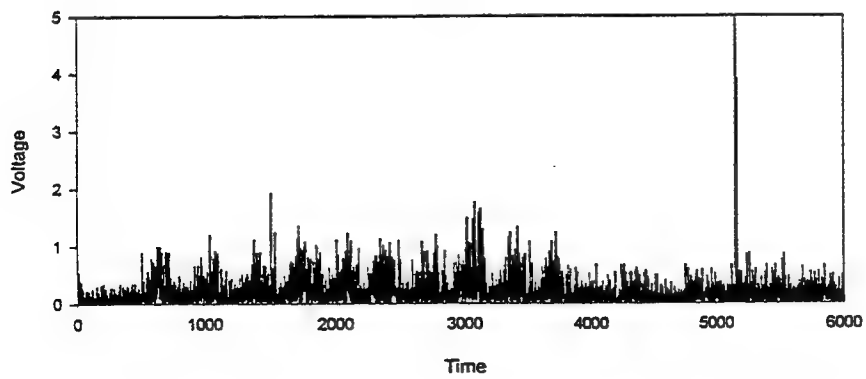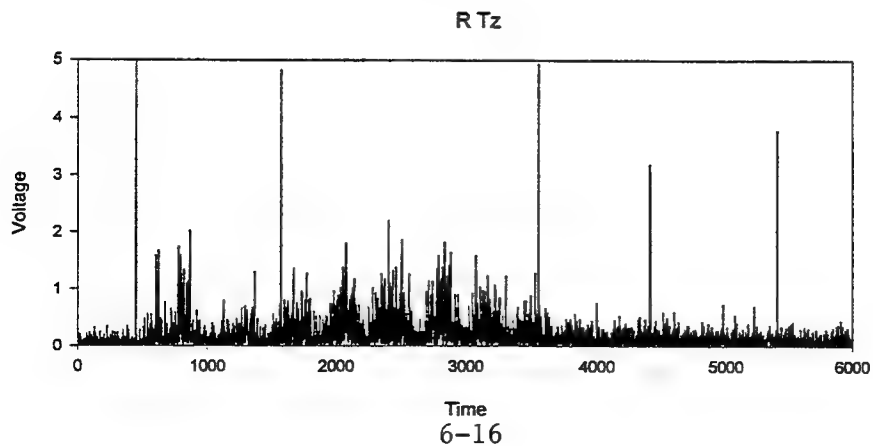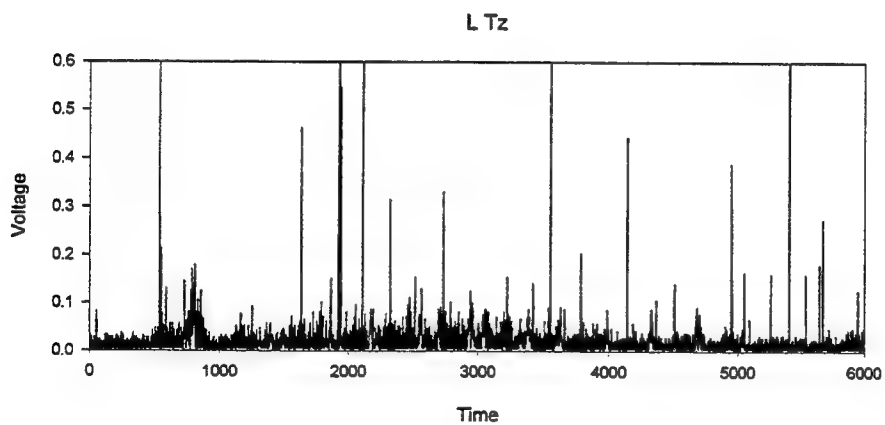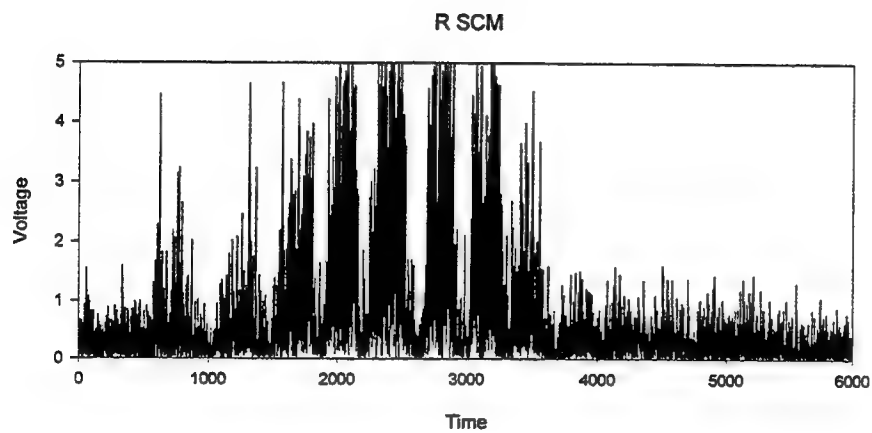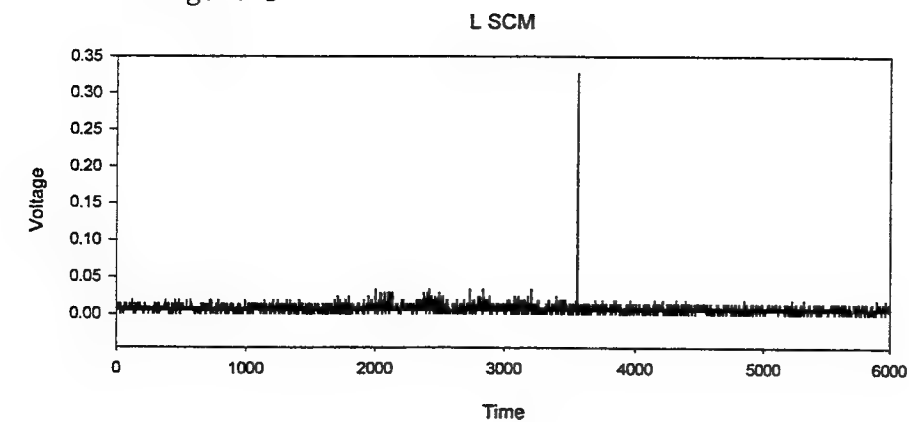
Figure 6

L SCM

R SCM

L Tz

R Tz

6-17

Figure 7

L SCM

R SCM

L Tz

R Tz

6-18
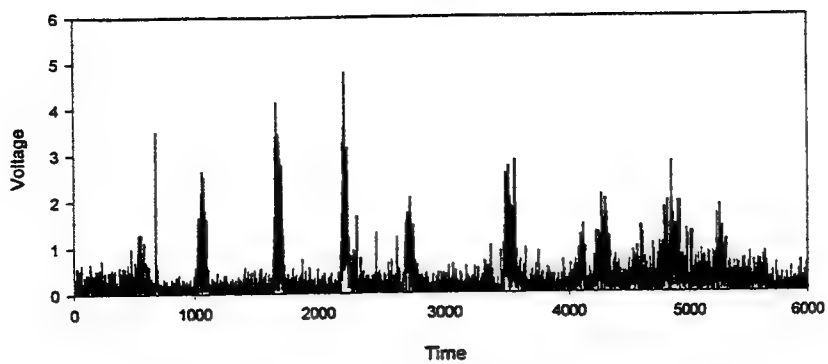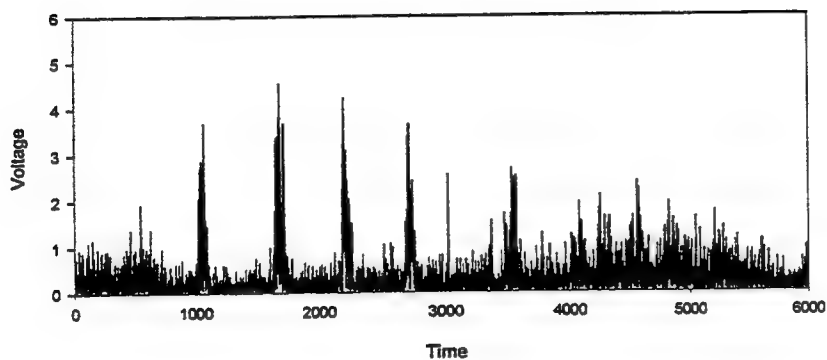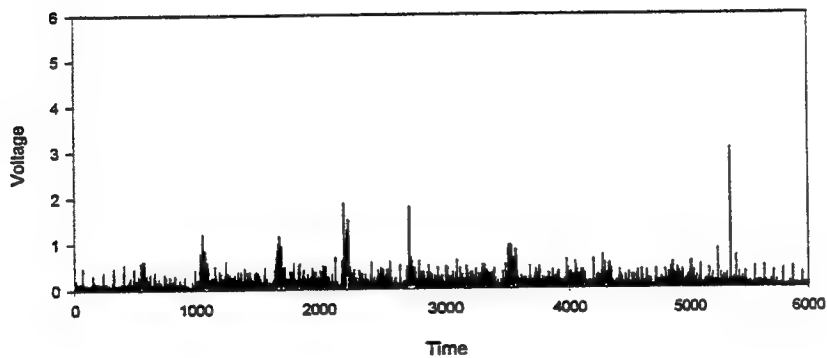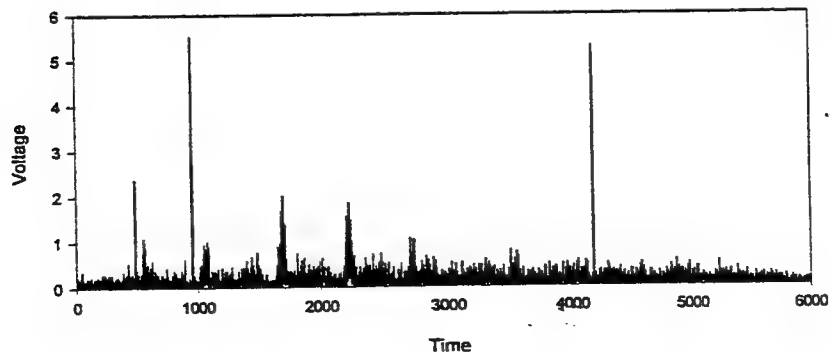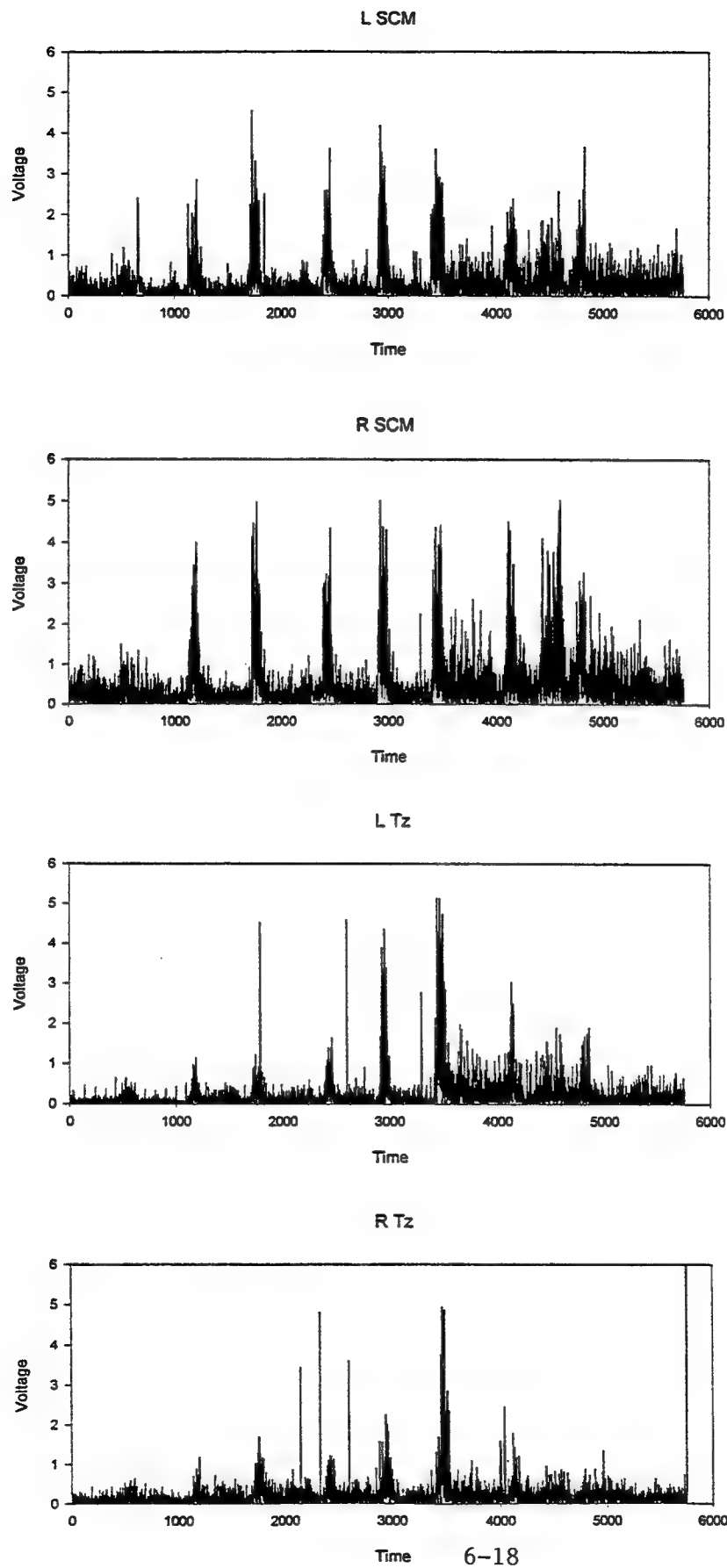
			Figure 8: MVC Values versus Rapid Run Values						

AVERAGE VALUES for Initial MVC: 25JY96A, 2000-4000

AVERAGE VALUES for Rapid run 25JY96B

MVC Values

3 G	601-800		

L SCM	R SCM	L Tz	R Tz			L SCM	R SCM	L Tz	R Tz
0.075746	0.124149	0.080289	0.008963			0.289526	0.335669	0.153638	0.019751

AVERAGE VALUES for Intermediate MVC: 25JY96C, 2300-3100

8 G	2401-2600		

L SCM	R SCM	L Tz	R Tz			L SCM	R SCM	L Tz	R Tz
0.247085	0.394337	0.237325	0.012978			0.738379	1.192798	0.43252	0.018042

AVERAGE VALUES for Final MVC: 25JY96E, 3000-4000

L SCM	R SCM	L Tz	R Tz
0.332217	0.253648	0.207102	0.014444

CORRELATIONS OF BODY
COMPOSITION AND VO2 MAX

Carolyn K. Chen

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

and

Armstrong Laboratory

·August1996

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CORRELATIONS OF BODY
COMPOSITION AND VO2 MAX

Carolyn K. Chen
Douglas MacArthur High School

Abstract

This project was designed to determine the correlations of body composition and maximal oxygen uptake (VO2 Max), comparing skinfold estimates and results of a treadmill test. The hypothesis is that a person with a lower percentage of fat and a higher percentage of lean mass will have a higher aerobic capacity, or VO2 Max.

The method of measurement for body composition was an application of a Lange skinfold caliper to estimate a percent body fat. Subjects also performed a treadmill test to measure their aerobic capacity (VO2 Max), for which they ran on a treadmill until they reached complete exhaustion. A comparison was made on various factors of the subject, including percent body fat, weight, height, VO2 Max (per kg of body weight), VO2 Max per lean body mass, age, weight of lean body mass, and fat weight.

The data showed that higher percent and weight of body fat correlated with VO2 Max. This corroborates data that suggests the more weight one had, the lower the VO2 Max. The last significant result was the comparison of analyzing one's aerobic capacity through the measurement of VO2 Max of body weight and the VO2 Max of lean body mass. The data showed that the VO2 Max per lean body mass probably measures one's aerobic capacity more accurately than the measurement of VO2 Max of body weight. The higher the percent body fat and the lower the percent lean body mass was associated with a lower maximal oxygen uptake (VO2 Max.)

CORRELATIONS OF BODY
COMPOSITION AND VO2 MAX

Carolyn K. Chen

Introduction

In this generation and many before, people have placed significant importance on their health and their body functions. Generally, body fat has been considered a liable way to measure one's performance of motor activities. Many investigators have examined the effects of various exercise and athletes to their VO2 Max. Research data suggests that anthropometric measures are better at estimating body composition than height and weight. Maximal capacity for oxygen consumption by the body during maximal exertion is known as maximal oxygen uptake (VO2 Max). The amount of energy required by the muscles increase when the body activity progresses from rest to exercise. Metabolism increases in direct proportion with rate of work. When the body has demands for increased energy, the body reaches a limit for oxygen consumption. Measuring the maximal oxygen uptake is a measure of aerobic fitness. It is defined by the condition when oxygen consumption reaches a peak and remains constant or drops slightly even when work intensity continues to increase.

Discussion of Problem

The relationship and comparison of a person's percent body fat and lean body mass to their maximal oxygen uptake was examined. I tested the hypothesis that the least amount of percent body fat and greatest amount of lean body mass would be associated with a higher maximal oxygen consumption (VO2 Max.) There is evidence to support the notion that less fat and more muscle in a person will be associated with higher aerobic fitness. Through a skinfold measurement and a treadmill test, this problem can be analyzed to tests its correlation.

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CORRELATIONS OF BODY
COMPOSITION AND VO2 MAX

Carolyn K. Chen

Methodology

There were nine healthy male subjects that had their body composition and VO2 Max calculated. Their age, height, and weight were measured. Their age ranged from 24-42 years old, height ranged from 163.8-191.3 centimeters, and weight ranged from 65.59-89.27 kilograms.

The skinfold fat measurements were taken on the right side of the body. The percentage of body fat was estimated by measuring skinfolds in six locations for men and five locations for women: triceps, subscapular, abdominal, suprailium, thigh, calf, and chest (in men only.) To measure the skinfold fat, the skinfold was grasped firmly by the thumb and index finger; the caliper was placed perpendicular to the fold at approximately 1 cm (1/4 to 1/2 inch) from the thumb and index finger. With a grasp on the skinfold, the caliper grip was released so that the full tension was exerted on the skinfold. In grasping the skinfold, the pads at the tip of the thumb and index finger were used. The dial on the Lange skinfold caliper was read to the nearest 0.5 mm approximately 1 to 2 seconds after the grip was released. A minimum of two measurements were taken at each site. If the repeated measurement varied by more than 1 mm, a third measurement was taken. The chest measurement was a diagonal fold taken one half of the distance between the anterior axillary line and the nipple. The triceps measurement was a vertical fold on the posterior midline of the upper arm (over triceps muscle), halfway between the acromion and olecranon processes; the elbow was extended and relaxed. The subscapular measurement was a fold taken on a diagonal line from the vertebral border to 1 to 2 cm from the inferior angle of the scapula. The abdominal measurement was a vertical fold taken at a lateral distance of approximately 2 cm from the umbilicus. The suprailium measurement was a diagonal fold above the crest of the ilium at the spot where an imaginary line would come down from the anterior axillary line. The thigh measurement was a vertical fold on the anterior aspect of the thigh, midway between the inguinal crease and the proximal border of the patella. To help locate the inguinal crease, the subject flexed the hip. The proximal reference point was located on the inguinal crease at the midpoint of the long axis of the thigh. The calf measurement was a vertical fold taken at the medial aspect of the calf, at the widest circumference measurement. A table was used to

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COMPOSITION AND VO2 MAX

Carolyn K. Chen

find the percent fat estimate based on age and sum of skinfolds for women and men. VO2 Max was determined during a maximal exercise tolerance test on a treadmill. The graded maximal exercise test to volitional fatigue consisted of an initial speed of 3.0 mph, 0.0% grade for 2 minutes. At this point the work rate was progressively increased to a maximum speed of either 7.0 or 8.0 mph, depending on the individual's heart rate, with grade remaining at 0.0% until reaching the maximum speed. Then speed was held constant and grade was increased to 3.0% for one minute, followed by 2.0% grade increases each subsequent minute. Subjects continued exercising until they were unable to maintain the running pace. They were verbally encouraged throughout the test to achieve a true maximal effort. Criteria for achieving a treadmill VO2 Max was obtained with a plateau in oxygen uptake with increasing work rate and respiratory exchange ratio values greater than 1.10. During the test, all subjects were continuously monitored using an EKG system. A twelve-lead EKG was done approximately every two to three minutes and heart rate is recorded every minute. At the end of the treadmill test, the maximum heart rate was recorded. Total subject time for the VO2 Max test was approximately 30 minutes. VO2 Max was calculated by ml/kg of body weight. VO2 Max per LBM was considered as ml/kg of lean body mass.

CORRELATIONS OF BODY

COMPOSITION AND VO2 MAX

Carolyn K. Chen

Results

There was a significant slope of the relationship between higher total weight and percent body fat and lower VO2 Max . (Figure 1 & 2). The subjects displayed that higher percent body fat was related to greater body weight. A comparison was done on the body weight with VO2 Max and lean body mass with VO2 Max to determine if VO2 Max of body weight or VO2 Max of lean body mass would be a more accurate reading of one's maximal oxygen uptake. It was suggested that the VO2 Max of lean body mass represents a more accurate reading of an individual's aerobic capacity. When determining the VO2 Max, body weight is supposed to be an adjustment to the different weights of various individuals, but according to Figure 3, using body weight is not an accurate form of measurement. There was a significant slope and therefore not showing a true value of one's VO2 Max. If VO2 Max of body weight was an accurate form of adjustment, then Figure 3 would have shown less of a slope. Since Figure 4 had less amount of slope, it reveals that the VO2 Max of lean body mass has a more accurate comparison of VO2 Max to an individual. Lean body mass is what consumes oxygen. The more lean body mass a person has, the greater the consumption of oxygen, which leads to a higher VO2 Max. The percent of fat of an individual is not metabolically active to predict one's VO2 max. Therefore, a better index in measuring VO2 Max would be by one's lean body mass than one's body weight. When comparing the body weight with the VO2 Max of lean body mass, another conclusion was found that there was no correlation as shown on Figure 5. Body weight does not play a role in determining one's lean body mass. Body weight cannot be used to predict a person's aerobic fitness. VO2 Max of lean body mass would be a more accurate form of measurement and adjustment to each individual.

CORRELATIONS OF BODY

COMPOSITION AND VO2 MAX

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Table 1.

Subject Descriptive Data

	subjects (n=9)
age, year	33±9.0
height, centimeters	178±14.5
weight, kilograms	77±12.5
% body fat	14±8.0
VO2 Max, ml/kg BW	51±12.5

CORRELATIONS OF BODY

COMPOSITION AND VO2 MAX

Carolyn K. Chen

Figure 1.
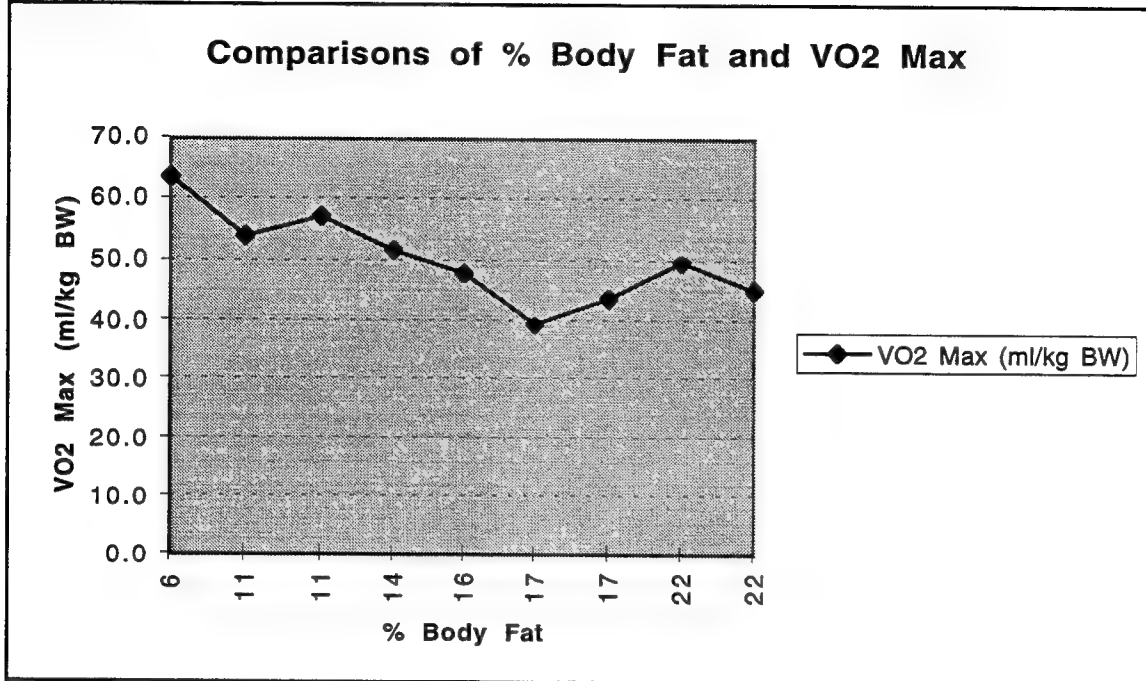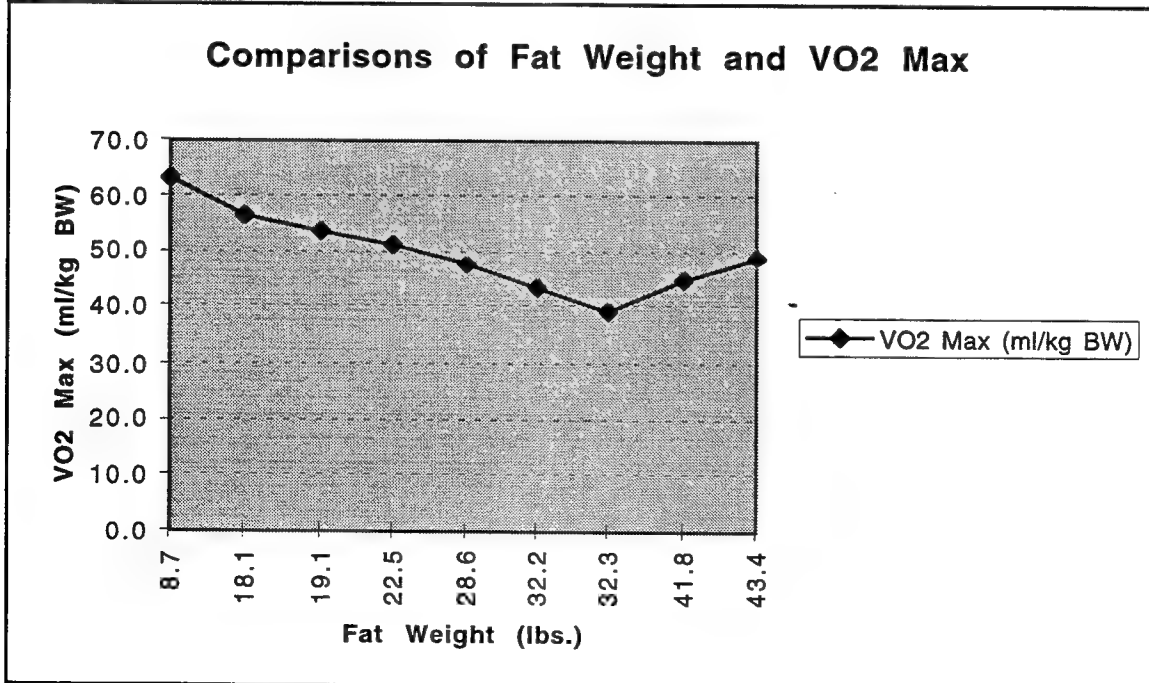
Comparisons of % Body Fat and VO2 Max

x-axis: % Body Fat — 6, 11, 11, 14, 16, 17, 17, 22, 22
y-axis: VO2 Max (ml/kg BW) — 0.0 to 70.0
Legend: VO2 Max (ml/kg BW)

Figure 2.

Comparisons of Fat Weight and VO2 Max

x-axis: Fat Weight (lbs.) — 8.7, 18.1, 19.1, 22.5, 28.6, 32.2, 32.3, 41.8, 43.4
y-axis: VO2 Max (ml/kg BW) — 0.0 to 70.0
Legend: VO2 Max (ml/kg BW)

CORRELATIONS OF BODY

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Figure 3.

Comparisons of Body Weight and VO2 Max

Figure 4.

Comparisons of Lean Body Mass and VO2 Max

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COMPOSITION AND VO2 MAX

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Figure 5.

Comparisons of Body Weight and VO2 Max LBM

Legend: VO2 Max (mL/kg LBM)

X-axis (Body Weight (kg.)): 65.6, 74.8, 75.1, 80.8, 81.8, 85.0, 85.5, 88.4, 89.3
Y-axis (VO2 Max (ml/kg LBM)): 0.0 to 70.0
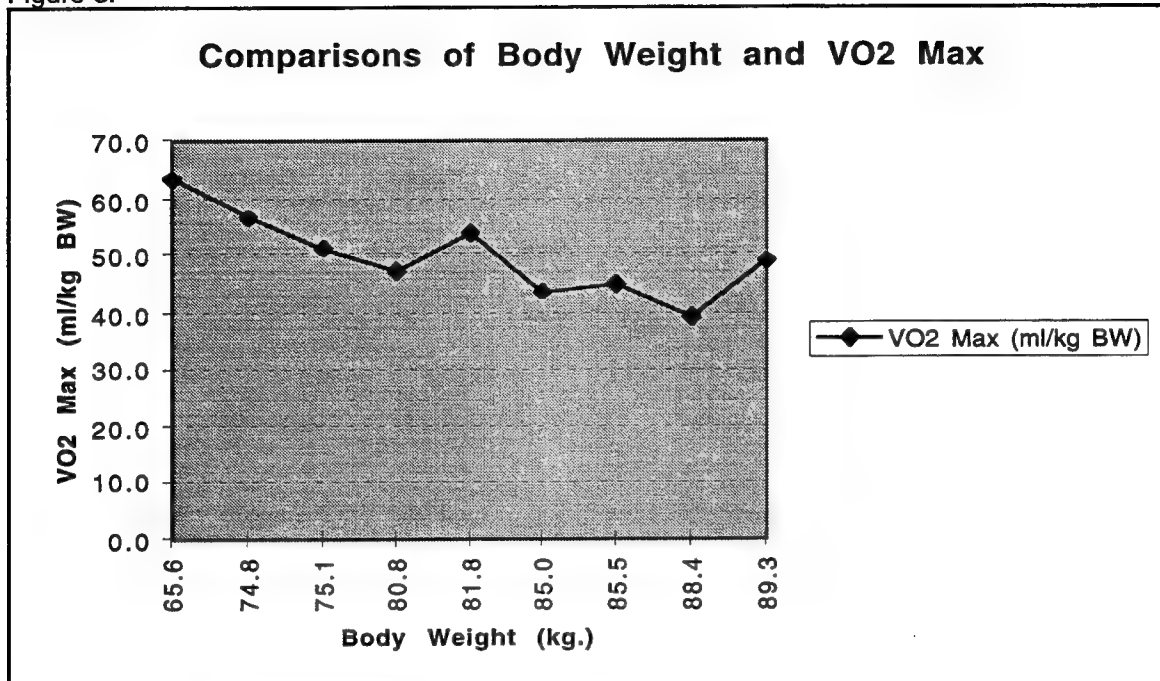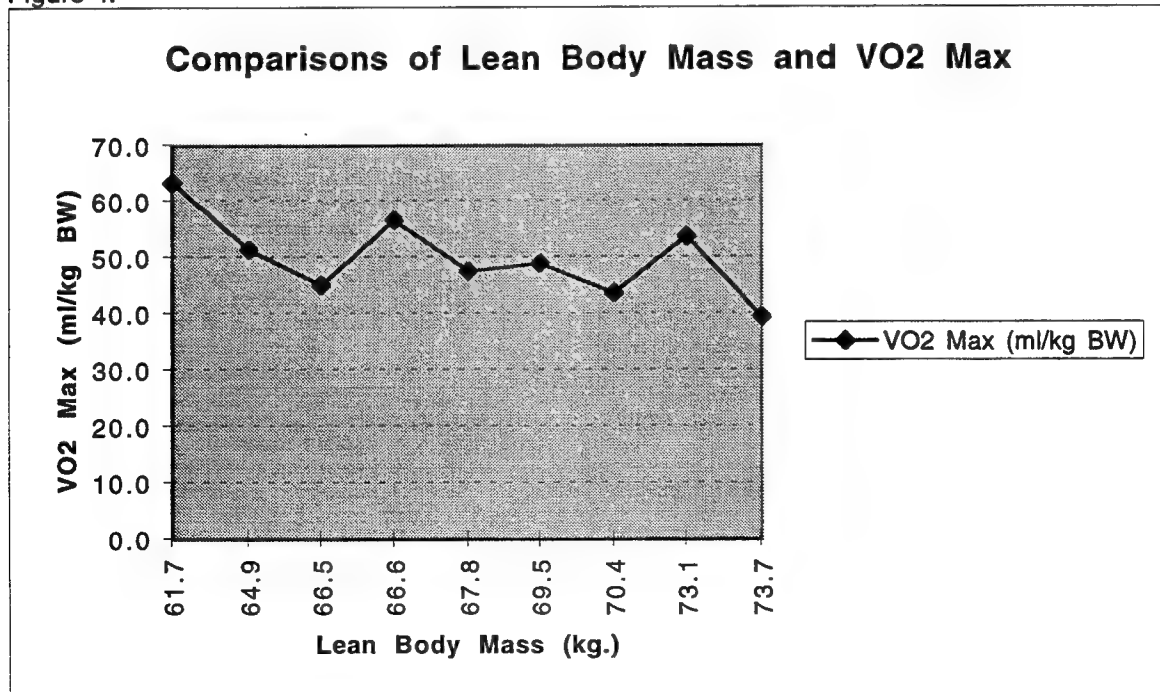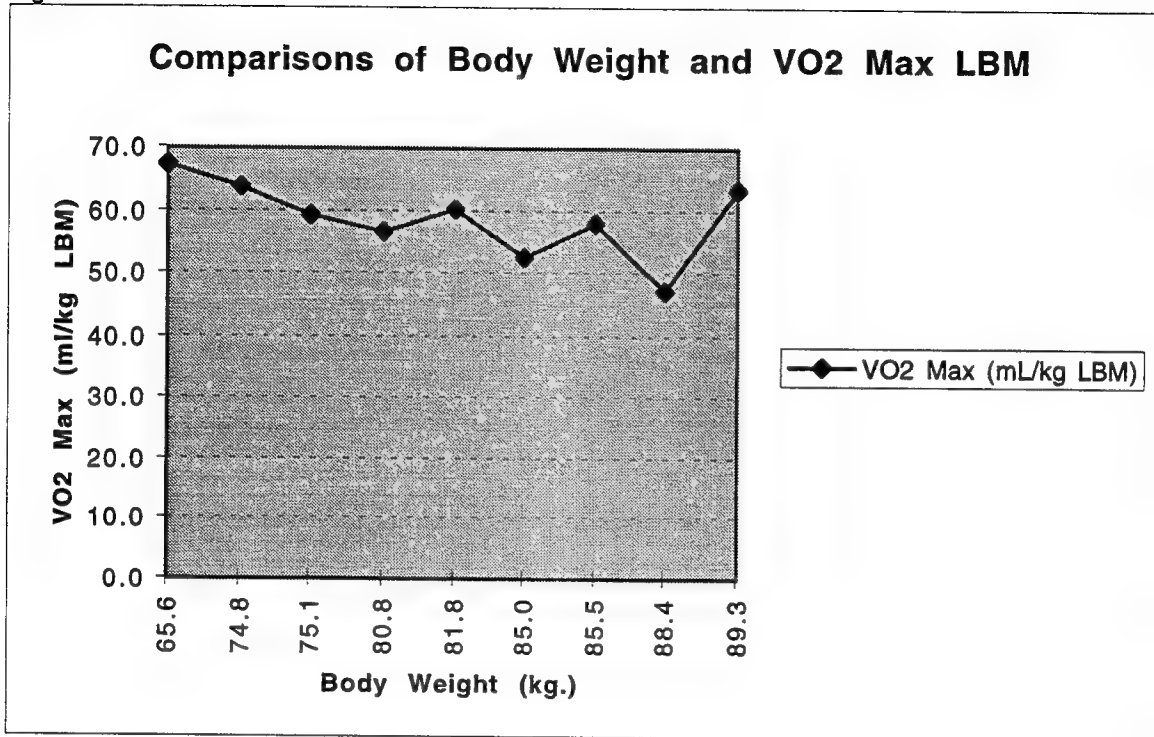
CORRELATIONS OF BODY

COMPOSITION AND VO2 MAX

Carolyn K. Chen

Conclusion

The results of this experiment supported my hypothesis that the higher one's weight percent body fat was associated with a lower VO2 Max. VO2 Max of lean body mass was found to be a more accurate reading of an individual's aerobic capacity. When applying VO2 Max expressed per lean body mass as the form of measurement, body weight had no correlation in determining a person's maximal oxygen uptake. These relationships may be best explained by the fact that oxygen consumption is performed by working muscle groups (lean body mass) rather than fat mass. Therefore, when a person has a higher percentage of body fat and a lower percentage of lean body mass, there is lower capacity for VO2 Max. This also explains why measuring VO2 Max per lean body mass would be a more effective reading than the measurement of VO2 Max per body weight. What is of greatest concern is the amount of lean body mass to determine an individual's aerobic fitness. These are the conclusions that were inferred from the experiment.

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COMPOSITION AND VO2 MAX

Carolyn K. Chen

References

Golding, L.A., Myers, C.R., and Sinning, W.E. Y's Way to Physical Fitness: The Complete Guide to Fitness Testing and Instruction. Champaign: Human Kinetics, 1989.

Pollock, M.L., Foster, C., Knapp, D., Rod, J.L., and Schmidt, D.H. "Effects of age and training on aerobic capacity and body composition of master athletes." Journal of Applied Physiology 62 (1987): 725-731.

Pollock, M.L., and Jackson, A.S. "Research progress in validation of clinical methods of assessing body composition." Medicine and Science in Sports and Exercise 16 (1984): 606-613.

Riendeau, R.P., Welch, B.E., Crisp, C.E., Crowley, L.V., Griffin, P.E., and Brockett, J.E. "Relationships of body fat to motor fitness test scores.' Research Quarterly 29 (1958): 200-203.

Stromme, S.B., Ingjer, F., and Meen, H.D. "Assessment of maximal aerobic power in specifically trained athletes." Journal of Applied Physiology 62 (1987): 725-731.

Wilmore, Jack H. Training for Sport and Activity: The Physiological Basis of the Conditioning Process. Boston: Allyn and Bacon, Inc., 1982.

Wilmore, Jack H., and Costill, David L. Physiology of Sport and Exercise. Champaign: Human Kinetics, 1994.

CORRELATIONS OF BODY
COMPOSITION AND VO2 MAX

Carolyn K. Chen

Consultation Resources

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

and

Armstrong Laboratory

August 1996

Consultation Resources

Christopher C. Garcia
Edgewood High School

Abstract

This summer my tour was at AL/OEBQ in the Air Quality Branch. Their main purpose is to make sure the Air Force is in compliance with the Clean Air Act, local, state, and federal regulations. Sometimes members of the staff will go (TDY) to an Air Force Base to collect ambient and source samples. Ambient samples are taken from the open air while source are taken from a specific location such as a smoke stack. Other times they will answer questions over the phone, often the answers will require some research. There are many documents such as technical reports (TR.) and EPA documents that assist the staff. This summer I organized those documents in a database, and organized them by placing them in easy to see binders.

Consultation Resources

Christopher C. Garcia

Introduction

When consulting sometimes the staff will refer to documents which can range from EPA Publications to technical reports, even books. These reports are stored in four basic locations ,the bookshelf (library) in the hallway, the "central" bookshelf (library), Major Kimm's office, and personal cubicles. These inefficiently stored documents were almost impossible to find. The books were a bit easier to locate, once you found where it was, because on the side of most books the title and author are printed. Unfortunately this often wasn't the case for the other documents. Occasionally the subject or title was written on the side but I can probably count those documents using my fingers. Another problem was nobody knew how many or even what documents existed, I later found out there was 200+ documents. The "library" in the hallway was shared with other departments such as hazardous waste management (departments are often know by what they work with, air, water, computer support, ect.) luckily for the staff the documents were not intermingled. The purpose of the database it to have a complete listing of all the documents and their location

Methodology

To solve this inefficiency of this government office I created a database of all the documents then arranged documents of the same subject in nice clearly labeled, easy to see binders. The database was constructed using Microsoft Access version 2.0. Since I did not know how to use Access, I couldn't get started right away. I was left alone in my little cubical to teach myself how to use Microsoft Access.

It took about two days to get a basic understanding of Access. I first read the Cue Cards (an assistance option) then I created a "dummy" database of made-up resources to get used to entering and manipulating data and the Query function. Learning the system was quite easy since it was user friendly and had "wizard" applications. "Wizards" are built-in database options that the user would simply customize into their own use rather than building a database completely from scratch. I was then ready to input data.

The database has seven fields. Fields are the vertical columns containing information about the records (rows, documents). The seven fields are subject, title, year of publication, agency, author, document

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number, and miscellaneous information. The subject was a general type subject and could not be too specific, since the query function uses this field. The title is simply the title of the document. The year of publication is simply the year it was published. The agency is who put out the document (EPA, OESO, ect), in the case of books the word "text" was put in to show that it was a text book. The author is who wrote the publication, not all documents had an author listed. The document number is the number of the document, not all documents had a document number and there were different types of document number formats, for instance, a technical report might have a number like this: ALOE-TR-89-039. An EPA document number may be like this: EPA/625/4-90/014 and there were many other variations. Miscellaneous information consisted of the contractor if the agency hired one and most important of all the location of the document. All of the fields are of the data type text, except for the year of publication which is of the data type number. The record (horizontal row) is the actual document information.

Once I created the form for the database I began entering in the data (documents). I entered over 200 documents into the database. I found the most difficult section to input was the subject because while some were easy to tell by the title others were very difficult (such as Sulfur Oxides Control Technology Series: Flue Gas Desulferization Dual Alkali Process).When ever I couldn't figure out the subject by title or by reading the abstract, I would ask the staff. I had to set the printer orientation to landscape in order to print out all seven fields and get the most information. The longest field is the title. In order to give the title as much room as possible I had to cut the other field titles. Year of publication went from year to yr, and document number went to "docnum". I trimmed most of the fields using the "bestfit" option, which trims it down to the letter so there is no extra space. Many titles were abbreviated, "control" became "ctrl" (look at your keyboard), "emission" became "emiss", ect. In long titles I left out insignificant short words such as "the" and "of".

It took me several weeks to input the documents since it consisted of over 200 documents. Once I inputed the documents, I created a "duplicate" query. This function of Access prints out a list of records with a similar field. I set it up so it would show all the documents with the same subject. At first it showed all the documents with duplicate subjects, but after slight modification it only showed the duplicates of the subject asked for.

The next task consisted of getting documents with the same subject together in binders. One problem was we needed binders. After cleaning out an office, we discovered a plethora of binders. First I emptied out the binders, all paper was recycled, then I put aside the binders in good condition, binders in bad condition were dealt with properly. The newfound plethora of binders were first kept at an indention in a hallway (made of cubical walls, the indention is there because of a post with a thermostat) labeled "If you need 'em Take 'em", with other binders. Then I cleaned a section of the hall library (the bookshelf in the hallway) by throwing away old documents that had already been replaced with superseding information, all paper was recycled, and the binders were placed there.

I would then receive stacks of documents of the same subject and on top of the stack a "sticky" had the subject of the documents on it. Then I went through the database and made sure all the documents were in the database and listed with the same subject. Next I would decide what size binder to use (a big one, medium, small) sometimes I would need to use more than one. In that case the first would be volume I, the second volume II and so on. In the binders the documents were separated by dividers. I had a binder full of dividers. Some dividers had numbers some had letters and some were thick paper or clear plastic slightly larger than a regular sheet of paper (8.5" x 11"). At first many of the dividers were not in order but I then put them in order. Most dividers went up to 5 (F if letters) but a few sets went up to 9. The number of documents was the number of dividers I needed. In the case of numbered dividers or lettered dividers it was which ever came first with the proper amount.

I then stacked the documents in the order they would go in the binder(s). Most of the time the I placed the documents in alphabetical order but for various reasons some were not in that order. Then I put the documents in the binders (all three-ring binders). Some documents had the binder holes already in them others did not. Some of the documents , that needed hole-punching, were thin enough to insert into the hole-puncher. The hole-puncher made nice big holes but would often get stuck in the down position and would take for ever to become unstuck. Some documents were very thick. Black clippy thingys called binder clips kept some of the thick documents together. I simply removed the binder clips and gave them to my mentor or who ever I was working with at the time. Other documents were held together by a rubbery type glue, in this case the pages were carefully stripped from the binding, this left a strip of a rubbery glue type substance

which was placed in a disposal unit (thrown in the trash). A very small number of documents were bound together by a metal clippy thingy contraption, which was easy to remove. Several documents were held together by normal staples, a staple remover sufficed. Many document were held together by big thick heavy duty staples, which took a very long time to remove. First I would "undo" the back of the staple, then I would slide one of the staple remover's "teeth" under the staple to make room for the other "teeth" . After battling with the staple for several minutes it would come out, looking like a straightened chewed-up paper clip, but I would often get little scrapes on my fingers and hands but nothing serious, it didn't bleed or anything. A few documents were held together by plastic spirals that were easy to strip away.

Once the documents were placed in the binders and properly divided two labels had to be made. The first label was for the front of the binder. This label consisted of the title of the binder, which was the subject of the documents, then the titles of the individual documents. The title is in all capital letters and in a font size of 36 and the document titles were of a font size of 24, but not in all caps. The labels were created in Microsoft Word version 6.0. Once the front label was completed I saved it because later other documents may be added. I used the numbering option icon to show the order of the documents. Sometimes the numbering option would be modified in the case of lettered dividers or more than one binder for a subject. After saving and printing the front label I would make the side label by deleting the document titles leaving the subject title behind. Then I would print that label. Sometimes I would have to change the orientation of the printer from portrait to landscape. All labels were proofread before printing to avoid paper waste, which really wouldn't be wasted because it would be recycled.

One day Msgt. Jag and I went through the library in the hallway. We found many old documents that were no longer needed so the paper was recycled (put in a storage place to be recycled to be exact). We got more binders and dividers (one set went up to 13) and documents. I kept the cover of the unneeded documents to make sure they were not in the database if they were they were then deleted.

The database was my major project but not the only thing I did during this tour. I assisted in the calibration of the mass flow meter of a big blue rectangular prism shaped thing called an air sampling meter box. A dry gas meter (a gray thing) would suck in air and measure its volume then the air would go through the mass flow meter of the air sampling meter. This was a two person operation. One person would watch

the meter on the dry gas meter and the other person would watch the meter on the air sampling meter. The person watching the dry gas meter would also time the meter to see how long it took to suck in a certain volume of air. When the dry gas meter took in the needed amount the time, and reading of the air sampling meter was recorded. Then some settings were changed some more data was recorded and the process began again until the necessary trials were completed. This was done for two air sampling meters box's.

While waiting for the dry gas meter to show the proper intake, I assisted Ssgt. Dobbins in filling jars with 200g of silica gel. The previous day the silica gel was heated to an extremely hot temperature to get rid of moisture. This process makes the silica gel a blue color. When it absorbs moisture from the air it becomes purple. After heating the silica gel must be allowed to cool before placing in the jar because if the jar is closed before cooling a vacuum seal will form making the jar almost impossible to open with out destroying the lid. We also weighed filters. The filters were weighed twice, each time after spending 24 hours in a dryer (desiccant chamber). I assisted in packing for a trip (TDY) to Hawaii, this was done in a building dubbed "the basement". I saw many probes and some equipment, once we were escorted by a security guard because the base was running threat-con exercises.

Results

The database currently holds 211 records (documents). Now that the documents are easier to find the employees will suffer from a little less stress.

Conclusion

The Air Quality Branch at AL/OEBQ runs more efficiently. This means the Air Force (a small portion) runs more efficiently. Which means the government is more efficient, which is something tax payers complain about. By the government becoming more efficient it saves money. In two years of this program I have learned that research isn't always "fun" lab work it can be boring. I still want to do research in a field of engineering. Every summer I have a good job with nice pay and work with great people. This is a good program and I wish I could return next summer but this program is for high school and graduate students.

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THE NEUROPHARMACOLOGICAL CHARACTERIZATION
OF G-INDUCED LOSS OF CONSCIOUSNESS

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NEUROPHARMACOLOGICAL CHARACTERIZATION OF G-INDUCED LOSS OF CONSCIOUSNESS

Lori J. Gilliam

Abstract

In order to unlock the secrets of gravitational induced loss of consciousness (G-LOC), the central nervous system's (CNS) regulators of consciousness were studied. Animal experiments were conducted to determine if pharmacological intervention could help prolong G-LOC induction time. Two experimental groups received a combination of cholinergic and adenosine compounds intended to prolong the G-LOC induction time. Moreover, the latter group was also treated with known cerebroprotective agents. Both treated groups resulted in the maintenance of prolonged EEG at all frequencies, which is suggestive of useful consciousness. Although the administration of the cerebroprotection compound had a severe sedative effect, it significantly reduced the amount of neurodegeneration.

NEUROPHARMACOLOGICAL CHARACTERIZATION OF G-INDUCED LOSS OF CONSCIOUSNESS

Lori J. Gilliam

Introduction

In recent years the Air Force has been building faster and better airplanes. Because of these high performance aircraft, the pilot becomes the limiting factor. Also, many accidents occur when a pilot loses consciousness while flying an airplane this incident is known as G-LOC or G-induced loss of consciousness. This experiment was designed to prolong G-LOC induction time through pharmacological intervention to determine if administered compound could possibly aid pilots in sustaining higher G-forces.

The central nervous system (CNS) is constantly trying to maintain homeostasis, or the bodies natural operating status. Exposure to G-forces interferes with this natural balance and deprives these CNS centers of blood and oxygen. In addition, the central nervous system is also bombarded by a multitude of signals coming in from the peripheral receptors. The true question is, can we help the homeostatic control centers to maintain a balance during +Gz exposure?

Several acute studies were performed on cholinergic, adenosine, dopaminergic, and glutaminergic, and GABAergic agents in order to find a possible agent or agents in characterizing the mechanism of G-LOC. Adenosine is a local paracrine neurotransmitter that is believed to play a role as an endogenous neuroprotective agent during cerebral ischemia. It is also considered to be a high pass filter that inhibits weak synaptic inputs, but facilitates the transmission of high frequency inputs. Caffeine, an A1 receptor agonist, was the first evaluated adenosine drug. Based on a dose response study, it was concluded that a concentration of 60 mg/kg results in the greatest amount of prolongation of G-LOC induction time.

The response study was performed on an A-1 receptor agonist, or N6-Cyclohexyladenosine. This study showed that doses greater

than 10 mg/kg was lethal; however, doses less than 3 mg/kg were ineffective. Although a 5 mg/kg dosage had no effect on G-LOC induction time, it severely affected EEG activity. The resulting brain waves contained mostly high frequency and low amplitude waves which were very abnormal. Finally, Propentofylline, an adenosine transport inhibitor, was tested. At 5 mg/kg this drug also resulted in a higher G-LOC tolerance. Interestingly enough, this increased in EEG was composed mostly of beta frequency. A selective characteristic that depresses the Delta, Theta and Alpha frequencies, while maintaining the Beta frequency.

The cholinergic system is located throughout the central nervous system. It is involved in such behaviors as sleep, locomotion, aggression, learning, and memory. This system mediates its effect via the G-protein coupled receptors. This system forms the interface between the sympathetic, parasympathetic, cardiovascular, and other regulatory systems. Based on preliminary studies with cholinergic drugs such as 3,4 Diaminopyridine, doses greater than 10 picomoles/kg are fatal, but prolonged the G-LOC induction time and severely depressed the cardiopulmonary system. Physostygmine, atropine, and SDZ ENA-713 were found to be ineffective. Pilocarpine mimics the body's parasympathetic activity, and it was used in this experiment to counterbalance the sympathetic induced reactions to acceleration stress.

Structurally and functionally, the central nervous system is subdivided into functional circuitries. The level of consciousness is believed to be controlled by the balance between the activation and inhibition of these circuitries. This study focused on neuropharmacological compounds in mediating or affecting these systems. From the above series of studies only a handful of agents were shown to have an efficacy to counteract this extreme condition. Therefore, the compounds which resulted in significant alterations of cortico-EEG activities were used in combination with each other; and these drugs were termed as Neuropharmacodynamic compounds. Moreover, to evaluate the benefits that can be achieved from this treatment the neuropharmacodynamic group is matched and compared with two other groups. A stressed control or a group

receiving no drugs; and a group receiving the same condition but given a pharmacological cerebroprotection.

Methodology

1. EEG surgery and +Gz exposure:

Adult, male, Sprague-Dawley rats were anesthetized using 3% halothane. A small area on top of the head was shaved and cleaned with iodine in preparation for surgery. A small incision was made to expose the skull, and four holes were drilled in order to implant the electrodes. Tiny metal screws were soldered to insulated wire for electrodes. These electrodes were implanted on the parietal bone and two on the frontal region for comparative differential recordings of the intra- and inter-hemispheric regions. The electrodes were assembled to a plastic pedestal and the incision was sutured exposing the pedestal. After a 24 hours of recovery, the rats were exposed to +25 Gz.

2. Drug Administration:

A combination of adenosine and cholinergic drugs were given intra-peritoneally 15 minutes prior to +Gz exposure to promote longer tolerance to acceleration. The neuropharmacodynamic drug consisted of 60 mg/kg of Caffeine + 5 mg of Pilocarpine + 5 pmol of 3,4 Diaminopyridine/kg of body weight. The cerebroprotection drug is composed of 5 mg of MK-801+ 5 mg of Propentofylline/ kg of body weight. Cerebroprotection was administered to protect the animals from the ill effects of cerebral ischemia.

3. Restraints and EEG computer:

The animals were restrained in small custom made Plexiglas restraint devices. These holders positioned the body and head at the correct +Gz alignment by locking the head forward with a bite bar. Padding was used to protect the animal from the plastic and restraint bar. The EEG pedestal and electrodes were then connected to the small animal centrifuge through a cable and an amplifier. EEG readings were collected through this device. These readings were generated, amplified, and hardwired from the centrifuge to the

Macintosh II FX via a pair of slip rings. An EEG calibration device assured accurate EEG readings. For raw data collection, an EEG strip chart was used. All EEG readings were analyzed with Labview software on a Macintosh Quadra 950.

4. Blood Chemistry:

After all the data was collected, the blood chemistry and EEG frequency analysis was studied using different chemical assays in order to read glucose and lactate levels. Also performed was the EEG frequency analysis, so that Delta, Theta, Beta, and Alpha waves could be read and interpreted.

5. Neuropathology:

Whole body perfusion, using hepranized 0.9% NaCl and 0.4% paraformaldehyde, was performed prior to brain extraction. Six coronal sections were embedded in paraffin and stained with hematoxylin and eosin (H&E). The CA-1 area of the hippocampus was analyzed for neuronal damage. Neuronal damage was assessed and graded using optical density and morphology.

Results

Please note that no statistical analysis has been done with this data, and the following results are preliminary.

As expected, the animals subjected to chronic stress resulted in hyperthropied adrenals which is an index of physical or chemical stress. The Y-axis is the weight of the adrenal gland normalized to the animals body weight. The X-axis represents the treatment groups. Chronic exposure to +25 Gz without drugs results in 61.609 ± 5.602 mg/kg of B.W. adrenal weight and treated groups result in 88.434 ± 11.218 and 70.638 ± 1.6496 respectively.

NORMALIZED ADRENAL WEIGHTS

TREATMENT GROUP
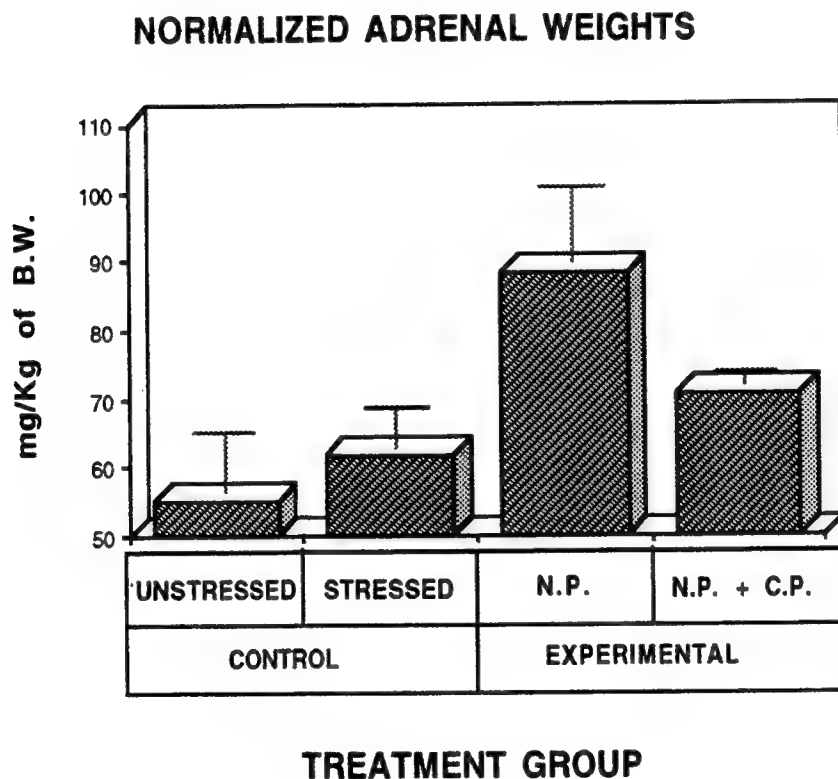
Exposure to the same condition results in 0.41±.38, 1.21 ± 0.36, 3.205 ± 1.74 and 5.585 ± .092 millimoles respectively.

The lactate value reflects the amount of stress we have given these animals as an acute effect as opposed to the chronic effect above. These results prove that the cerebroprotection is not of immediate help, but after chronic exposure it protects the animal.

LACTATE
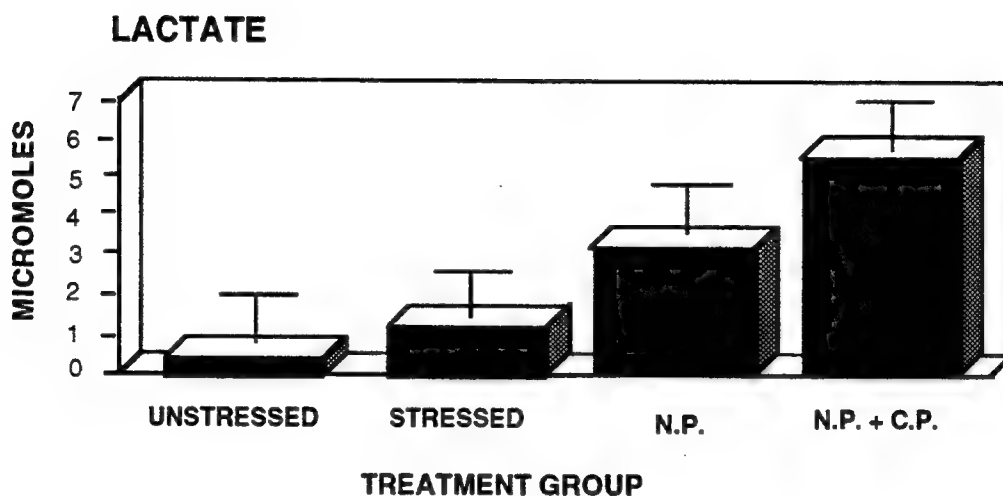
No difference in G-LOC induction time was observed between the two treated groups 2 days post experimentation. The day 2 graph represents experimental progress. As expected, the neuropharmacodynamic group and the neuropharmacodynamic + cerebroprotection group, show much longer EEG activity post acceleration as compared to control

DAY 2
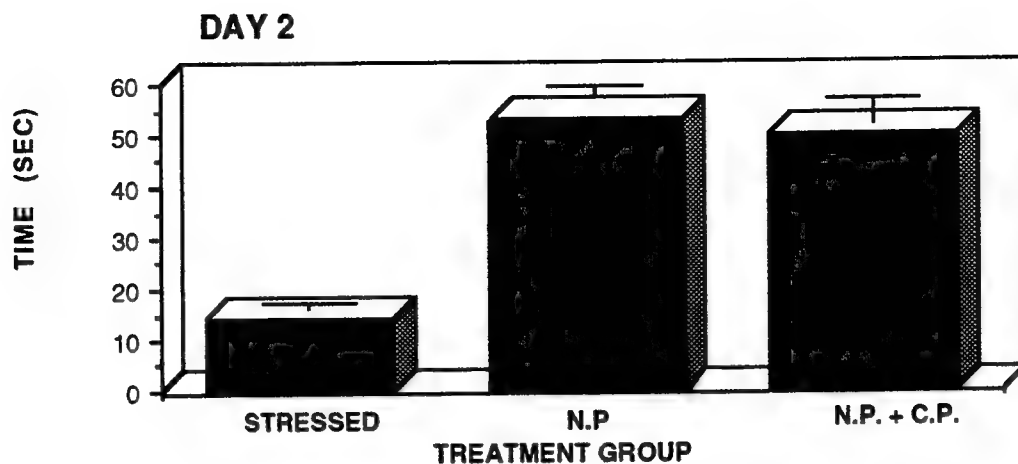
Day 7 showed that the group given the cerebroprotection maintained longer duration before G-LOC, as compared to the neuropharmacodynamic group who reduced G-LOC induction time. The stress controls have G-LOC at approximately 14 seconds. The neuropharmacodynamic group and the neuropharmacodynamic + cerebroprotection group have extended G-LOC time by 6.5 fold.

DAY 7
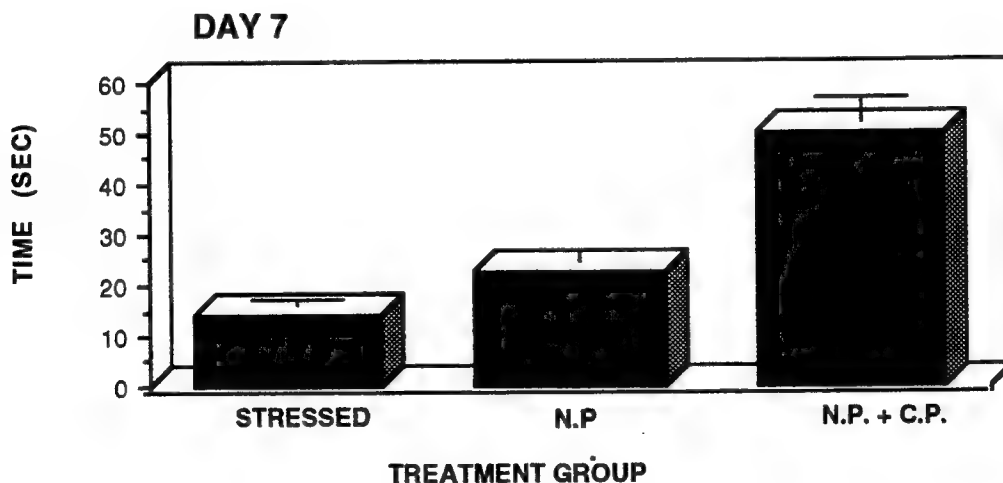
The difference between the control values and the experimental values is at all frequencies. All frequencies are maintained at certain percentage of the baseline value. As an example, the Delta wave is shown below. The white line is the acceleration plateau, and the vertical lines demonstrate the difference between the control G-LOC point and the drug band G-LOC point.

COMPARATIVE EEG FREQUENCY ANALYSIS

DELTA FREQUENCY (1 - 4 Hz) :
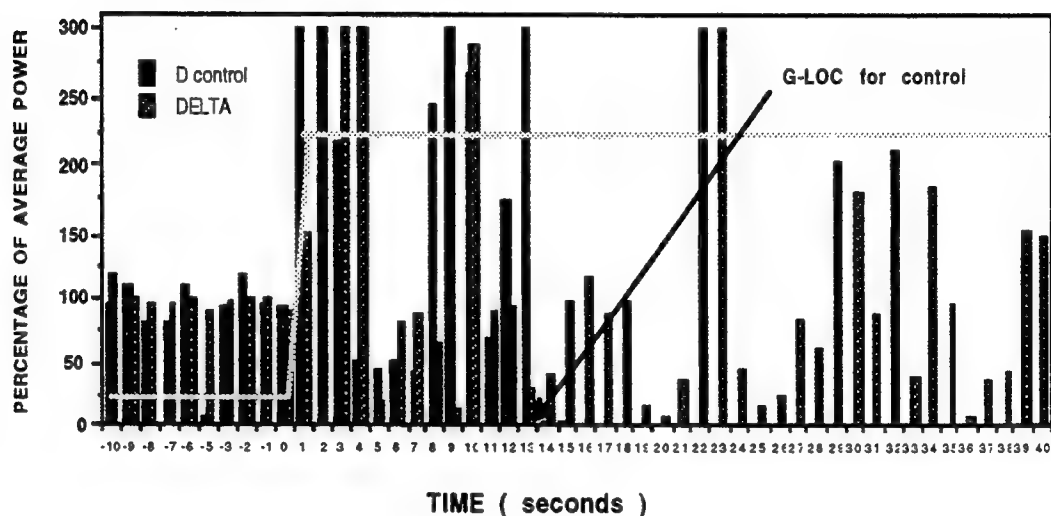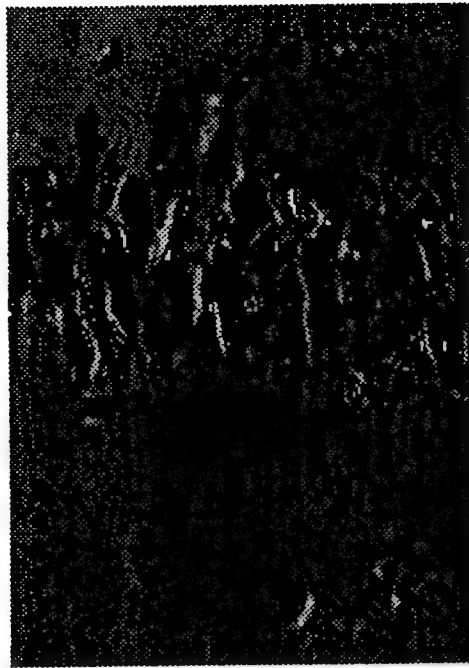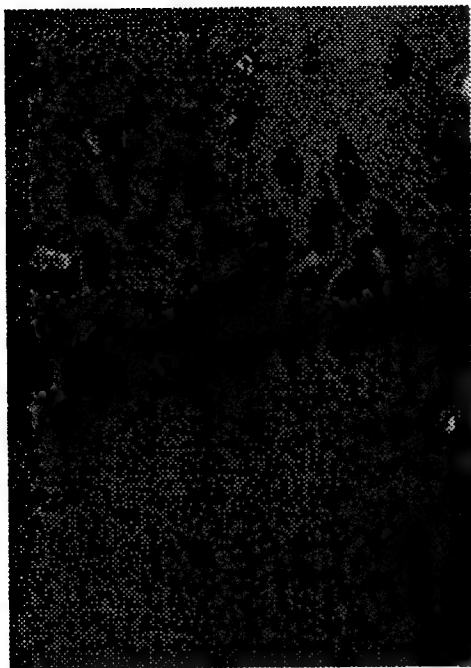
The CA-1 area of the hippocampus is known to be selectively damaged by cerebral ischemia. The photograph on the left is a representative of normal cells, while the photograph on the right shows the damaged neurons. Damaged cells are characterized by dark elongated neurons. The group that received cerebroprotection had significantly reduced neural degeneration induced by chronic exposure to +25 Gz forces as seen in the next graph.

NEUROPATHOLOGY
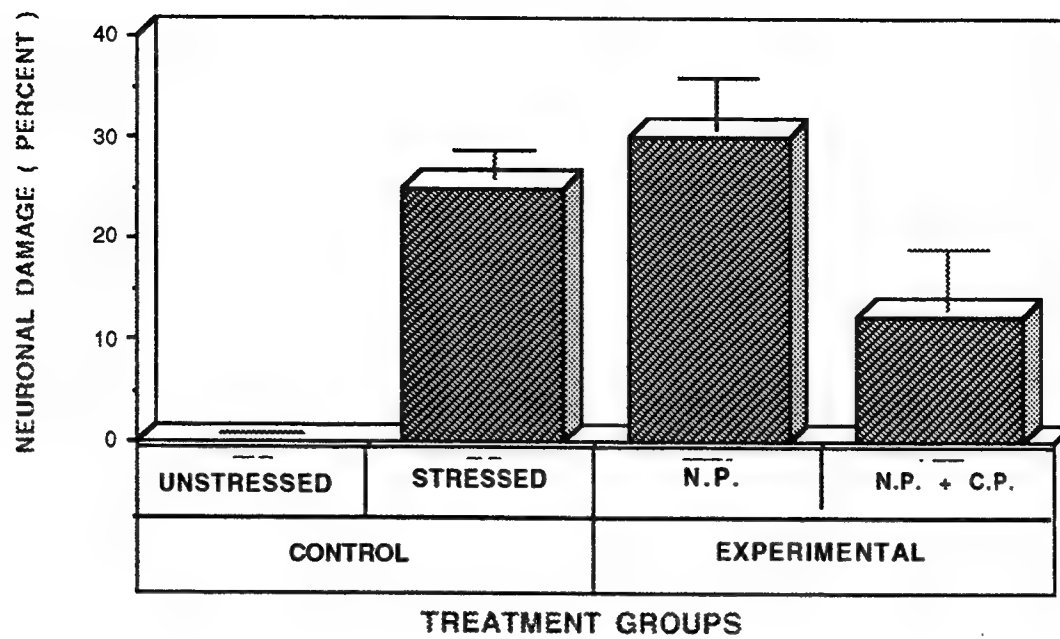
Discussion

Adenosine modulates the release of certain inhibitory neurotransmitters on a calcium dependent basis. Antagonizing this system using caffeine results in the prolongation of EEG activity. Whereby utilizing an agonist results in the opposite and much altered EEG pattern. Many of the cholinergic and noncholinergic compounds acting on pre- and post-synaptic mechanisms failed to effect the EEG activity of the small animal centrifuge G-LOC model. 3,4 Diaminopyridine and Propentofylline are two compounds that significantly alter the EEG patterns in our model. However, the resulting EEG patterns are of questionable status. The prolonged EEG activity obtained using 3,4 Diaminopyridine is composed mostly of high frequency low amplitude waves. Propentofylline results in the maintenance of the Beta wave. The significant increase in G-LOC induction time obtained using the neuropharmacodynamic compounds result in the maintenance of EEG at all frequencies.

Conclusion

The combination of inhibitory and excitatory compounds results in the prolongation of EEG activity at all frequencies suggests a possibility of continued or useful consciousness. The administration of cerebroprotection post ischemia significantly reduced the occurrence of selective neurodegeneration; however, administration of this compound results in a long lasting sedative effect. The reticular formation and the intralaminar thalamic nuclei are the known structural regulators of consciousness; therefore, the known inhibitory and excitatory pathways of these structures need further evaluation.

References

Brodal Per, (1992) Reticular Formation. *The Central Nervous System.* **12**: 285-301

Jin S., znd Fredholm B. B. (1994) Role of NMDA, AMPA and kainate receptors in mediating glutamate- and 4-AP-induced dopamine and acetylcholine release from rat striatal slices. *Neurophar.* **33**: 1039-1048.

Parkinson F. E., and Fredholm B. B. (1996) Adenosine A1 and A2A receptors and nitrobenzylthioinosine-sensitive transporters in gerbil brain: no changes following long-term treatment with the adenosine transport inhibitor propentofylline. *Neurophar.* **35**: 79-89.

Rudolphi A. K., and Fredholm B. B. (1992) Adenosine and brain ischemia. *Cereb. and Brain Meta. Review.* **4**: 346-369.

Sadoshima Seizo, and Ibayashi Setsuro (1995) Inhibition of acetylcholinesterase modulates the autoregulation of cerebral blood flow and attenuates ischemic brain metabolism in hypertensive rats. *J. Cereb. Blood Flow and Meta* . **15**: 845-851.

Watt R. C. and Hameroff S. R., (1988) Phase space analysis electriephalography (EEG): A new mode of intraperative EEG analysis. *Int. J. Clinical Monit. and Comp.* **5**: 3-13.

"EASY REFERENCE"
PSYCHOLOGICAL REFERENCE PAGE CREATOR

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

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"EASY REFERENCE"
PSYCHOLOGICAL REFERENCE PAGE CREATOR

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Abstract

"Easy Reference" is a program that, given a partial or complete psychological citation, searches a database of psychological references and displays matches to the user who can subsequently insert said references into an automatically created reference page. This program takes the tedium out of creating reference pages based on citations within theses. "Easy Reference" was written in WordBasic and utilizes SQL (Structured Query Language) to search an Access database located on a public network drive. Possible extensions of "Easy Reference" include a document "scanner" which searches through a document and automatically creates references for every recognizable citation, and an advanced search search which finds references in the database containing a combination of Author, Title, Date, and Publication.

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Introduction:

Anyone who publishes scientific papers is faced with the task of creating a reference section for each citation contained within the document. These reference sections are tedious to manually create as they may be pages long. This is especially applicable to the psychologists working in the Human Resources Department of Armstrong Laboratories. "Easy Reference" was envisioned to ease the creation reference sections and in the process save many man-hours.

Methodology:

Microsoft Word 6.0 being the dominant word-processing program at Armstrong Laboratory, "Easy Reference" was written as a WordBasic macro. Early versions of "Easy Reference" called upon a table stored in a Word document which held the psychological references parsed into the following fields: Type, Authors, Date, Title, and Publication. The Type field was a numerical value indicating whether the reference was a journal, book, or of other nature. The front-end of "Easy Reference" consisted of a dialogue box with several radio buttons and an text box. After selecting radio buttons for the type of reference and the field to search in, the user entered the search string in the text box. This early version of "Easy Reference" performed a field-specific double-wildcard (any matching sub-string with a field) search, finally grafting together the constituent fields of matches into complete references. Because of its inefficient search and crude data storage and manipulation, it accommodated approximately sixty-nine references—a rather minuscule amount. Since "Easy Reference" was planned to ultimately accommodate thousands of entries, it soon became obvious that both a more efficient storage method and faster search algorithm was needed. Microsoft Access provided a convenient solution, able to easily interface with Microsoft Word. A simple macro was used to read through

a document containing a list of personal references from several volunteers, parse these references, and save them in a text file. The text file was then imported into Microsoft Access, to create a test database. At this point the Access database still comprised of rows of parsed references (five fields). To accomplish the task of accessing an external database through Word, Open Database Connectivity (ODBC) was implemented. ODBC uses SQL (Structured Query Language) to query an external database and return the results of said query. Early versions of the Microsoft Access-based "Easy Reference" worked well with a database of a few hundred references. Once there were upwards of two-thousand references, "Easy Reference" became intolerably slow. The original argument for storing the references in a five-field format was to enable the user to search for particular references on any of the five fields. This format, though, slowed down the search considerably. Because citations are in the form of "author, author, etc., date", only two fields need be searched in an automated process. Since the purpose of "Easy Reference" was to be a tool that could quickly, and without hassle, search for a more or less accurate string, the fields were reduced to Author and Reference, Reference being the complete and unparsed reference to be inserted into the reference section. Along with this change in format, the database was broken down into tables by year, producing twenty-six (1970 - 1996) sub-databases. This format considerably increased the speed of the search. Along with this format was the removal of the default double-wildcard search. This meant that the program would assume that the first author specified in the citation was actually the first author in the reference. To accommodate those users who would specifically want to search using double-wildcards (e.g.: the first author's name was unknown) this assumption could be overwritten by placing a percent sign (SQL wildcard) in front of the first author. The change in search policy, compounded with the effects of the change of database format, produced a program which could search for a reference in three seconds, where earlier versions would take three minutes. This success prompted the download of thousands of Psychlit references on CD. A conversion program was created to extract the reference information from downloaded Psychlit references into a plain-text, field-delimited format, readable by Microsoft Access. This text was then imported into Microsoft Access to create the final database. To further improve the efficiency of "Easy Reference", a local database, a small text file

containing frequently used or slow to access references, residing on the hard drive of the user's computer was implemented. References that took over thirty seconds (by default) to find would automatically be stored in the local database. Furthermore, the user could choose specific references to add to the local database from those that were presented in a successful search. The current version of "Easy Reference" automatically searches the local database before searching the large, and potentially slow, global database. If matches are found in the local database, the user has the option to toggle to the global database. If no matches are found, the program skips to the global database. After the matching references are displayed to the user, the user has the options of adding them to the local database (if they were found in the global database), toggling to the other database, and inserting a reference. The "Easy Reference" database is currently stored on the network at Armstrong Laboratory so anyone with a copy of "Easy Reference" may access it.

Conclusion:

Although "Easy Reference" is a success its applications can be extended. Under refinement is a fully automated "Easy Reference" document "scanner" which will be able to read through a document, recognize any citations it comes across, and insert references into a reference section, displaying any errors encountered on a separate page. Another possibility, for those who want to search the large reference database by specific fields, is an "Easy Reference" advanced search, allowing users to search for one or more strings in several fields.

IN-VITRO SIMULATION OF PHYSIOLOGIC AORTIC PRESSURE AND FLOW PROFILES

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Final Report for:
High School Student Research Program
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IN-VITRO SIMULATION OF PHYSIOLOGIC AORTIC PRESSURE AND FLOW PROFILES

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Abstract

A Cardiovascular Dynamics Simulation Modeling (CDSM) System was developed to simulate aortic pressure and flow waveforms of *in vivo* measurements in Rhesus monkeys. The CDSM system consists of a programmable pump and motion controller, a computer data acquisition system, and a closed flow loop assembly. Physiologically equivalent aortic pressure and flow profiles were reproduced in the CDSM system by matching time and frequency domain characteristics of the CDSM system to the Rhesus data. Model and hemodynamic parameters were matched with varying success, as heart rate and mean aortic pressure agreed to within one percent, while stroke volume, cardiac output, systolic and diastolic aortic pressures, and pulse pressure showed marked deviation (12.3% - 110.6%) from target values. Computational errors and limitations of the experimental model were responsible for some of these differences. Overall, the CDSM system was determined to be an acceptable mechanical model of the cardiovascular system for the testing and evaluation of electrical analog models of the arterial system.

IN-VITRO SIMULATION OF PHYSIOLOGIC AORTIC PRESSURE AND FLOW PROFILES

Gregory T. Hannibal

Background

Exposure to micro- and hypergravity environments in aviation produces changes in cardiovascular function as seen in pilots and astronauts. These changes can result in G-induced loss of consciousness (G-LOC) experienced by pilots, or orthostatic hypotension in astronauts upon returning to 1 a Gz environment. Systemic arterial compliance (SAC) and total peripheral resistance (TPR) may play an important role in understanding the regulatory mechanisms governing these cardiovascular changes. A variety of lumped parameter electrical analog models of the arterial system have been developed allowing investigators to estimate SAC and TPR [1-5]. Validating these model estimates has been difficult due to the invasive procedures required to obtain experimental data. Therefore, a mechanical model of the circulatory system was developed to simulate physiological data and to provide real SAC and TPR measurements for testing the accuracy of the electrical analog models. A primary objective in the development of the cardiovascular dynamics simulation modeling (CDSM) system was to develop the capability to produce physiologically equivalent aortic pressure and flow waveforms. A secondary objective was to duplicate hemodynamic parameter values such as stroke volume, cardiac output, heart rate, mean aortic pressure, and aortic systolic and diastolic pressures. Therefore, the goal of this study was to demonstrate the CDSM system's ability to simulate physiological data by accomplishing these objectives.

Methods

The CDSM system (Figure 1) is comprised of a linear displacement pulsatile pump (Dyantek Lab., Inc., Galena, MO) and motion controller (Ormec Motion Controllers, Rochester, NY), a closed flow loop, and a computer system for controlling the pump. The flow loop consists of ventricular and atrial chambers made of Plexiglass, flapper and synthetic tricuspid valves representing the mitral and aortic valves, various clamps and tubing, In-line pressure-flow modules®, and a venous return chamber. A compliant tube and a screw clamp were used to model the lumped parameters SAC and TPR. A custom software package allows the user to define pump parameters that include heart rate, stroke volume, cardiac output, and systolic and diastolic time intervals. Additionally, analog feedback allows the user to set upper and lower thresholds for maintaining a specific

hemodynamic parameter at a defined point [6]. For example, cardiac output can be set to 1 L/min by programming the pump to adjust heart rate or stroke volume independent of pressure, TPR, or SAC.
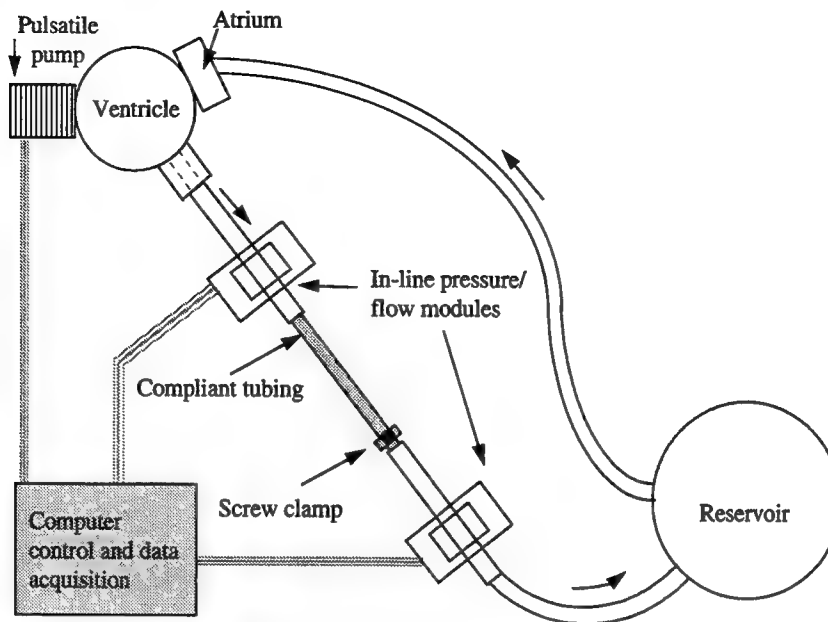
FIGURE 1: CDSM system setup

Pressure and flow readings were measured by a Triton active-redirectional transit-time flow probe and a Konsigsberg absolute pressure transducer [7-8]. A custom-designed Plexiglass tube that houses these sensors without disturbing the flow profile through the tube was fabricated. These In-line Pressure-flow Modules® were placed upstream and downstream from the mechanical model test section (compliant tubing). One module was placed upstream from the test section for measuring aortic pressure and flow (input). A second module was placed downstream from the test section for measuring output pressure and flow. Real-time resistance and compliance were calculated using the pressure and flow readings from both modules [9]. Rhesus monkey data obtained experimentally from a head-down tilt study (control state) were used as the target physiological values for the study. Typical physiological aortic pressure and flow waveforms and average hemodynamic values are shown in Figure 2 and Table 1.

SUBJECT	AoP$_{MEAN}$	AoP$_{SYS}$	AoP$_{DIA}$	AoP$_{PP}$	CO	SV	HR	SAC	TPR
1	88.9	109.9	71.2	38.7	1307.8	7.8	166.8	0.1166	0.0723
2	94.5	115.8	76.3	39.6	1304.2	8.4	154.9	0.1140	0.0767
3	107.5	128.1	89.1	39.0	1429.6	8.3	171.8	0.0971	0.0774
4	101.3	120.0	85.1	34.9	1127.9	6.8	165.2	0.0982	0.0959
5	90.1	106.1	72.6	33.5	1168.7	8.0	146.2	0.1298	0.0808
6	91.5	111.6	72.8	38.8	861.2	6.8	127.0	0.0950	0.1076
MEANS	95.6	115.2	77.8	37.4	1199.9	7.7	155.3	0.1085	0.0851

TABLE 1: Normal steady state hemodynamic values recorded in Rhesus monkeys (n=6).

> **Note:**   AoP=aortic pressure (mmHg)   CO=cardiac output (ml/min)
>   SV=stroke volume (ml)   HR=heart rate (beats/min)
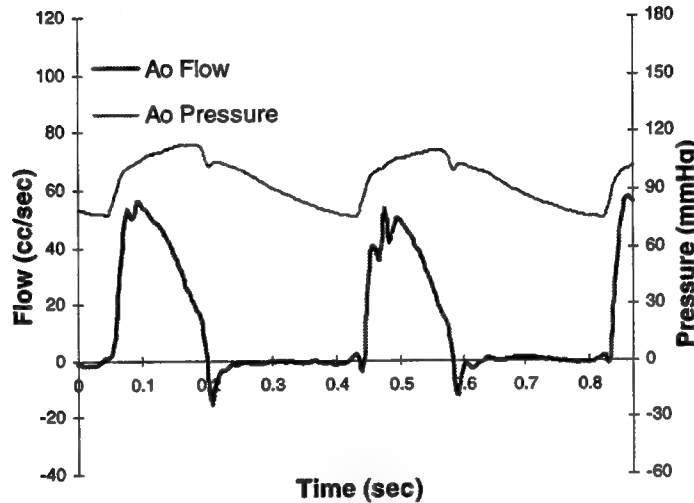
FIGURE 2: Aortic (Ao) pressure and flow waveforms recorded *in vivo* in a Rhesus monkey during steady state.

The experimental approach for this study consisted of trying to match the *in vivo* (rhesus) and *in vitro* (CDSM system) aortic pressure and flow waveforms by "fitting" the input impedance of the mechanical model to the rhesus data. This was accomplished by adjusting the dimensions of the compliant tubing and the location and number of turns (aperture) of the screw clamps. Heart rate and stroke volume settings were programmed to reflect physiologic values (*in vivo* data). Pressure and flow waveforms were recorded at varying heart rate and stroke volume settings (Table 2). The desired cardiac output levels were achieved and held constant during each trial by use of the analog feedback feature, and mean aortic pressure set to ≈95 mmHg by adjusting (tightening) the screw clamp. A two element Windkessel model was used to estimate the SAC and TPR of the *in vivo* and *in vitro* data [1].

TRIAL	1	2	3	4	5	6	7	8	9
STROKE VOLUME (ml)	4	6	8	4	6	8	4	6	8
HEART RATE (bpm)	130	130	130	150	150	150	170	170	170

TABLE 2: individual trial settings for stroke volume and heart rate

Results:

The best model fit was achieved using a compliant tube 7.5 inches long, 0.62 inches in diameter, and with a wall thickness of 0.045 inches. A single screw clamp was placed at the end of the compliant tube. The hemodynamic parameter values achieved using the CDSM system are shown in Table 3. Aortic pressure and flow waveforms produced by the CDSM system are illustrated in Figure 3.

RUN	AoP$_{MEAN}$	AoP$_{SYS}$	AoP$_{DIA}$	AoP$_{PP}$	CO	SV	HR	SAC	TPR
1	94.9	120.3	62.6	57.7	781.2	6.1	128.2	0.0289	0.1199
2	93.4	118.5	61.2	57.3	779.3	6.1	128.2	0.0293	0.1185
3	94.6	129.7	53.9	75.8	1050.7	8.2	128.0	0.0346	0.0909
4	93.5	127.6	52.8	74.8	1090.6	8.5	127.7	0.0319	0.0890
5	98.8	142.3	50.3	92.0	1430.7	11.2	128.2	0.0314	0.0744
6	97.5	139.3	49.5	89.8	1453.3	11.3	128.2	0.0315	0.0724
7	93.0	119.1	60.1	59.0	918.7	6.2	148.4	0.0244	0.0959
8	94.5	119.1	63.0	56.1	931.1	6.3	148.5	0.0252	0.0969
9	99.0	131.7	56.0	75.7	1289.8	8.6	149.0	0.0258	0.0739
10	93.4	125.8	51.0	74.8	1318.6	8.9	148.6	0.0256	0.0702
11	97.6	141.0	42.0	99.0	1702.6	11.5	148.2	0.0238	0.0582
12	98.1	140.0	43.2	96.8	1733.5	11.7	148.4	0.0235	0.0592
13	92.7	116.9	59.5	57.4	987.8	5.9	168.3	0.0264	0.0977
14	94.1	116.6	62.8	53.8	1014.4	6.1	167.6	0.0279	0.0966
15	99.1	128.6	58.0	70.6	1425.1	8.5	168.4	0.0309	0.0737
16	96.8	127.2	55.9	71.3	1443.7	8.6	167.8	0.0296	0.0696
17	94.3	137.0	38.5	98.5	1880.0	11.3	166.2	0.0268	0.0523
18	95.9	137.4	40.7	96.7	1932.3	11.5	168.0	0.0269	0.0523
MEANS	95.6	128.8	53.4	75.4	1286.9	8.7	148.1	0.0280	0.0812
% ERROR	1.0	12.3	32.3	110.6	41.8	47.5	1.4	67.6	45.8

TABLE 3: hemodynamic parameters for *in vitro* data; individual runs, means, and percent error from *in vivo* data. The same symbols are used as in Table 1.
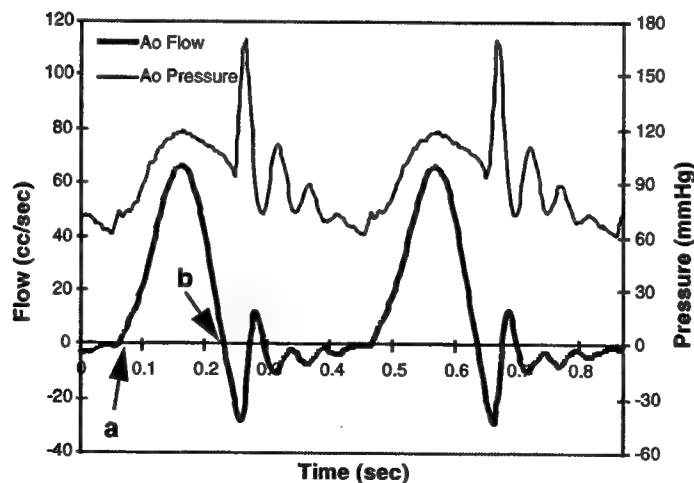
FIGURE 3: An aortic flow and pressure waveform produced by the CDSM system during one trial.

The shape of the aortic pressure and flow profiles produced by the CDSM system data matched the *in vivo* data reasonably well. Heart rate and mean aortic pressure of the *in vitro* system were within one percent of *in vivo*

values. Mean systolic and diastolic pressures of the *in vitro* system were noticeably higher (systolic by 12.3%) and lower (diastolic by 32.3%) than *in vivo* measurements (i.e. the pulse pressure was greater). This trend was also seen in the simulated aortic flow waveform. Further, the pressure and flow waveforms showed disturbances during diastole, and the dichrotic notch was more pronounced.

Discussion

The pressure and flow waveforms produced by the CDSM system were a close match to the *in vivo* waveforms. However, there were some differences between the magnitudes of several hemodynamic parameters. Differences in aortic pulse pressure exhibited the greatest error (110.6%). There are two possible explanations for this occurrence. First, the compliant tube used in our mechanical model test section may have been too elastic. An increase in pulse pressure (ΔP), which is a function of compliance and change in volume ($\Delta P = \Delta V/C$), will result if the tube compliance is too low (or elastance too high) and if the volume gradient (ΔV) does not vary. Therefore, a low compliance value resulted in a higher systolic pressure. The magnitude of this problem could be reduced by increasing the diameter or length, decreasing the wall thickness, or altering the mechanical properties of the test tube. Second, lower diastolic pressures may have been a result of back-flow through the aortic valve, which caused the volume of the tube to decrease too rapidly. Ultimately, a large difference in pulse pressure, defined as the difference between systolic and diastolic pressures ($AoP_{PULSE} = AoP_{SYSTOLIC} - AoP_{DIASTOLIC}$), occurred and resulted in a large percentage error. The cardiac output and stroke volume of the *in vitro* system were higher than the *in vivo* values, as a result of a computational error. The mean flow (L/min) of the pump was programmed to match the target value. However, the stroke volume equation, calculated by integrating the flow waveform (Figure 3), excluded the negative flow portion of the waveform during diastole. Thus, the programmed stroke volumes and cardiac outputs (CO =SV x HR) were larger than the target values. This problem also resulted in underestimation of TPR. Solutions to this problem could include minimizing the backflow through the aortic valve or incorporating a correction factor. Additional factors that contributed to differences in the pressure and flow waveforms included physical characteristics of the pump system and the inefficiency of the aortic and mitral valves. The physical dimensions of the CDSM system are much larger ($\approx$10 times) than the anatomically normal heart (rhesus). The Plexiglass atrium, ventricle, and aorta components of the CDSM system also differ greatly from the bio-mechanical

properties of the myocardium, as the model materials are much less compliant (more elastic). The mechanical valves used in the CDSM system had greater back flow than would occur *in vivo*. Preliminary research, independent of this study, indicated that multiple screw clamps positioned along the compliant tube improve the characteristics of the simulated aortic pressure and flow waveforms [6, 10].

Conclusion

We were able to demonstrate that the CDSM system can function as a viable simulator of the cardiovascular system. The mechanical model produced aortic pressure and flow waveforms that closely matched those of experimental data. The CDSM system has been used to assess accuracy of the parameter estimates of several electrical analog models of the arterial system [9,10]. Improvements in performance of valves and tubing, and application of multiple screw clamps in the flow loop assembly should improve the characteristics of the simulated aortic pressure and flow waveforms. Ongoing development and refinement of the CDSM system should ultimately allow investigators to test scientific hypotheses in a controlled environment, and provide a tool for educating scientists and engineers in basic hemodynamic relationships.

Acknowledgments

References

[1] Self DA, Ewert DL, Swope RD, Crisman RP, and Latham RD. "Beat-to-Beat Determination of Peripheral Resistance and Arterial Compliance During +Gz Centrifugation," *Aviation Space Environmental Medicine.*, 65: 396-403, 1994.

[2] Toorup GP, Westerhof N, Elzinga G. "Beat to Beat Estimation of Peripheral Resistance and Arterial Compliance During Pressure Transients," *American Journal of Physiology*, 252: H1275-H1283, 1987.

[3] Toy S, Melbin J, Noordergraaf A. "Reduced Models of Arterial Systems," *IEEE Trans. Biomedical Engineering*, 32(2): 174-176, 1985.

[4] Yin F, Liu Z. "Estimating Arterial Resistance and Compliance During Transient Conditions in Humans," *American Journal of Physiology*, 257:H190-H197, 1989.

[5] Essler S. "Estimation of Arterial Vascular Parameters for Transient and Steady Beats," *Masters Thesis*, North Dakota State University Electrical Engineering Department, 1995.

[6] Schaub JD, Koenig SC, Offerdahl CD, Ewert DL, Swopes RD. "Cardiovascular Dynamics Simulation Modeling System," *Advances in Physiology Education,* (in review).

[7] Koenig SC, Schaub JD, Ewert DL, Swope RD. "In-line pressure flow module for *in vitro* modeling of hemodynamics and biosensor validation," *Med. & Bio. Eng. & Comput.*, (in review).

[8] Koenig SC, Reister CA, Schaub JD, Swope RD, Ewert DL, Fanton JW. "Evaluation of Transit-Time and Electromagnetic Flow Measurement in a Chronically-Instrumented Non-Human Primate Model," *Journal of Investigative Surgery*, (in review).

[9] Schaub J. "In-Vitro Evaluation of Lumped Parameter Arterial Models of the Cardiovascular System," *AFOSR Graduate Student Research Program (Final Report)*, August 1996.

[10] Offerdahl C. "Development of an In-Vitro Circulatory Model with Known Resistance, Inductance, and Capacitance," *AFOSR Graduate Student Research Program (Final Report)*, September 1995.

NEUROPSYCHOLOGICAL
TESTING OF PILOTS

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NEUROPSYCHOLOGICAL
TESTING OF PILOTS

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Abstract

Neuropsychological testing is administered UPT pilots, the normal pilot population, and certain special cases. Neuropsychological testing is a factor in the selection of pilots, is used when pilots are having certain problems, and is given under other special circumstances.

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Neuropsychological testing is a very important tool in assessing the personality/abilities of pilots and in helping with problems they might be having. UPT pilots are tested to see if they have the personality traits common to pilots, and their results are a factor in whether or not they become a pilot. Pilots with head trauma, depression, alcohol problems, marital problems, and many other such neurological/psychological problems are also tested. There are special cases in which non-pilots and special groups, such as helicopter pilots and gunners are tested, as well.

Many different tests are given. Some personality batteries that are given are: the Minnesota Multiphasic Personality Inventory (MMPI), the NEO Personality Inventory Revised (NEO-PIR), the Millon Clinical Multiaxial Inventory-III (MCMI-III) the Personal Characteristics Inventory (PCI), the Cornell Index, the Beck Depression Inventory (BDI), the Structure Sentence Completion Test, the Recent Life Events questionnaire, the Cockpit Management Attitudes Questionnaire (CMAQ), and the Aircrew Coordination Survey. The MMPI, NEO-PIR, MCMI-III,and PCI are all used to determine personality characteristics. Cornell Index is a true/false questionnaire that asks personal questions. The BDI is used to determine the presence and the level of depression of a patient. The Structured Sentence Completion Test is a page of half written sentences which the patient must finish with the first thing to come to mind. The Recent Life Events questionnaire asks the patient if specific things have happened within the last year and to rate them in order to determine factors that might be leading to problems a patient is having, or factors caused by problems they are having. The CMAQ and Aircrew Coordination Survey are specifically for pilots, navigators, and aircrew to determine their attitude and approach towards their job.

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The other category of tests is the neuropsychological battery. Included are: the Weschler Adult Intelligence Scale Revised (WAIS-R), the Multidimensional Aptitude Battery (MAB), the Selective Reminding test, the Grooved Peg Board, the Weschler Memory Scale Revised (WMS-R), and the Halstead-Reitan Battery. The WAIS-R and the MAB are IQ tests. The Selective Reminding test tests for head injury by having a list of words is read to the patient that must be repeated. Patients must insert grooved pegs into a pegboard as fast as possible in the Grooved Peg Board in order to test for mental slowing. The WMS-R is a memory test in which current events, digits, letters, words, time, and place must be recalled.

The Halstead-Reitan Battery is a series of tests for head trauma which consists of: the Aphasia Screening Test, the Category Test, the Finger Tapping Test, the Grip Strength, the Seashore Rhythm Test, the Sensory-Perceptual Examination, the Speech Sounds Perception Test, the Tactual Performance Test, and the Trail Making Test. The Aphasia Screening test screens for a partial loss of speech or comprehension resulting from brain damage. The Category Tests use a series of visually presented items to assess brain damage. In the Finger Tapping Test the patient taps their finger as many times as possible for ten seconds, and the results can indicate brain damage. The Grip Strength test is used to detect differences in hand strength to determine if there is lateral brain damage. The Seashore Rhythm Test is a measure of attention and concentration in diagnosing brain damage. In the Sensory-Perceptual Examination parts of the body are touched singly and simultaneously to assess brain damage. In the Speech Sounds Perception Test the patient hears nonsense syllables and must answer which one he is hearing on a multiple choice answer sheet to determine left brain damage. The Tactual Performance Test tests tactile memory to assess brain

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damage. The Trail Making Test involves connecting circles to measure visual conceptual and visuomotor tracking.

Specific combination of these neuropsychological tests are given to different cases. The pilot's tests are administered at Brooks AFB in San Antonio, Texas and Wright-Patterson AFB in Ohio.

The Study and Application of
C++ Programming

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High School Apprentice Program
Armstrong Laboratory

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July 1996

The Study and Application of
C++ Programming

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Abstract

The computer programming language of C++ was studied. Along with assisting with other tasks in a robotics laboratory, the best course of action appeared to be to learn a high - level language since no resources other than computers were available to research with and all of the work done was through computer programs. A "Teach Yourself" book was thoroughly studied through reading, typing in sample programs, and by answering review questions. Knowledge of the language was acquired and then applied toward assisting in a program to operate the Automated Ordnance Excavator, which was undergoing the process of being changed into a vehicle operated by remote control by a laptop computer.

The Study and Application of

C++ Programming

Eric W. Inge

Introduction

C++ is currently a programming language used by many programmers in the workplace. Bjorn Stroustrup developed C++ which is based on the language C. C++ has the features of using supporting libraries so that only the types of pre-defined code used will be included in the compiled program. Programming in C++ was done using the Visual C++ Workbench. The Robotics Laboratory at Wright Laboratories on Tyndall Air Force Base takes develops autonomous ground mobile robots - sometimes by renovating older machines to operate by remote control.

Methodology

The study of the language C++ was undergone through self-study with the use of written materials. First, a book explaining the language C was read to learn the foundations on which C++ was built. Then the book Teach Yourself Visual C++ 2 in 21 Days Third Edition by Namir Clement Shammas was studied in depth. Each chapter consisted of text explaining an aspect of programming, several examples of programs illustrating the specific aspect just explained, and a review section that includes a Question and Answers section to clarify common questions, a quiz, and some practice exercises in programming. Over one-hundred and seventy-five sample files were typed in throughout the course of study to create sample programs given. Around 30 sample programs were created in response to exercises posed by the book.

The book was proceeded through chapter by chapter. Chapter 1 presented background information on the language and explained how to operate the workbench in order to create programs. After learning how to operate the workbench, a very simple program was created. Chapter 2 explained the basic parts of a program along with how to name and declare variables and constants. The use of functions was also

discussed along with static variables, inline Functions, default arguments, and function overloading. In

Chapter 3, operators and expressions were dealt with. These included arithmetic operators, arithmetic

expressions, the *sizeof* operator, relational and logical operators, Boolean expressions, bit-manipulation

operators, and the comma operator. The concepts of operator precedence and evaluation direction along

with the feature of typecasting a value to a different data type. The managing of input and output was then

brought to the forefront in Chapter 4 introducing a feature that was not in C. Stream input and output

change the whole method in which a program has the computer process data in interactions with the user.

The older method used in C of printf was also brought up to show some advantages in controlling the look

of the output. Decision-Making Constructs were discussed in Chapter 5. *If*, *else*, and *switch* statements can

control the direction of the program depending on the values of the data. Chapter 6 introduced the time and

code saving feature of loops, which can perform a task over-and-over again exactly the amount of times

needed. *For* loops perform a loop as many times as a condition is met while its counter is incremented or

decremented. *While* loops perform a loop if the beginning condition is true. *Do-while* loops perform a loop

once and repeat if a condition is true. The rules for nested loops, loops placed within loops were also given.

Arrays and matrixes were presented in Chapter 7. Arrays are variables that can contain multiple amounts of

data stored by index. The data usually is similar and part of a group. Arrays make sorting and searching

data simple. The QuickSort, Shell-Metzner Sort, and Comb-Sort Methods are introduced as various ways

to sort data depending on which is more valuable - time or code-space. Binary and linear searches are

introduced. For small arrays linear searches are quick enough and simple to code in. For larger arrays,

binary searches work well as they cut the amount of the array by half with each search until they zero in on

a match. After the first seven chapters, a review section demonstrated many different features together in a

sample program.

Then the more advance features of the language were presented in the next seven chapters. Chapter 8

showed the use of user-defined types and pointers. Type definition, enumerated data types, structures,

unions, and reference variables are presented as user-defined types. Accessing and manipulating data

without changing the original value of the variable was shown to be done with pointers. Pointers serve as practicable tool in performing tasks in everyday programming. Different aspects of pointers are discussed along with commands such as new and *delete* and the difference between far and near pointers. Strings, grouped characters, are introduced in Chapter 9. Compared to other languages C++ introduces this concept much later in its texts, because of the complicated nature of using many different string libraries to utilize the wealth of commands optional to manipulate the data. Chapter 10 discusses advanced function parameters. Passing variables to functions must be done specific manner to avoid losing or unintentionally altering data. Special rules are used to pass arrays, pointers, strings, and parameters involving structures so the language can utilize its highly advanced features. The concept of Object oriented programming is introduced in Chapter 11. Classes can be used to most effectively group data together to quickly perform functions and operations in a simple manner. Just having a program perform a task is not always enough in programming. The speed at which it executes, the size of the program, and the accessibility to be altered and interacted with can become important. Classes have many features that can be used which involve knowing the use of constructors, destructors, virtual functions, operators, and friend operators at the least. Programs can not often practicably include everything they need in one file. Chapter 12 demonstrates the use of stream file input and output. One file can open, read, or write to another file that may contain data or something else needed. Different features of this concept include sequential text, sequential binary, and random access file stream input and output.

The book then entered the area of Windows programming, which with the prevalence of Microsoft operating systems has become often a necessary area into which programs must be written. Chapter 13 explained the Microsoft Foundation Class library and how it is applied to programming in C++. Chapter 14 demonstrated how to create applications for Windows using the MFC library. Opening and closing windows and adding items to the command bar are discussed. A short review section followed after which the chapters continued. The next seven chapters explain how to make Windows applications that use the different classes within the MFC library. Chapter 15 explained how to scroll through text in windows using

different method varying in complexity. Chapter 16 demonstrated MFC controls. The process of creating static text dialog boxes and manipulating the text within it afterwards was described. The CEdit and CButton classes are introduced. Using buttons and messages within becomes an important task to learn. Chapter 17 discusses Grouped Controls such as the check box control, the radio button control, and the group box control. Check Boxes show a check within a box or an empty box. Radio buttons are circles that can be empty or have within a colored in circle. Group Boxes puts together the buttons within a box. These buttons can indicate when something is in use or if a feature of the executed program is turned on or off. Chapter 18 presents the class CListBox which can create boxes useful within windows. These boxes can when scrolled show a list of data to chose from, either previously used data or default items. This feature makes a program more user-friendly. Many functions can be used within this class to transfer data about. Chapter 19 involves scroll bars and combo boxes. The CScrollBar class helps operate scroll bars that can move back forth the image on the screen if it is smaller than the window. Combo Boxes give users the choice of choosing data from a list such a list boxes do or to give new data such as edit boxes do. Chapter 20 presents the feature of dialog boxes. These are little windows that can show data or let data be entered in. Modal dialog boxes gain the users full attention as they must be dealt with before any other part of the program can be proceeded with. Modeless dialog boxes can be open while other things are being done. The process of creating, using, and transferring data for dialog boxes are discussed in detail. Multiple Document Interface Windows was studied in Chapter 21 which is useful in dealing with child windows. After a review section five bonus sections of the book were read through. They include working with the AppWizard, invoking the ClassWizard, using OLE 2.0 features, using the Database features, and working with C++ Templates.

The knowledge acquired in programming was then applied to a project being worked on at the Robotics Laboratory.

Results

The study of C++ then resulted in assisting with a program to operate the Automated Ordinance Excavator. As a result of the closing of military bases land was in the process of being transferred to private control. Some test sites have the danger of still holding mines and explosives within them. The AOE has the responsibility of digging up detected materials. It must be operated by remote control since it would be hazardous to have a manned vehicle handle explosives. A program was in the process of being created to operate the machine by a laptop computer. Assistance was given to the creation of program in areas that the researcher was capable of programming. One example is that the program that had been written to operate it was in need of a menu item to call up a screen to monitor the diagnostic functions on the machine. Using the resource editor and then by editing the code, the knowledge of programming just acquired was applied to create a screen (see Appendix A) and assist in its addition to the program, including the interactions between the main program and the data presented in the screen.

Other Tasks

The researcher was given various tasks to assist in or perform as needed. If someone working on a machine needed an extra hand to help repair it, for example replacing a part, the researcher took a few minutes to help out. If an engineer within the building was busy with a project and needed something researched on the Internet to find critical information the researcher would assist in that.

The researcher spent two weeks assisting in field tests on the Subsurface Ordnance Characterization System. This robotic vehicle detects ferrous materials such as mines using a magnetometer. The researcher helped set up the test range by laying out a course of two lanes north-south and two lanes east-west. These lanes ran along or perpendicular to magnetic field lines. The course was set up using Global Positioning Satellites, a compass, and a tape measure. The course had to be cleared of ferrous object by a hand-held metal detector. The purpose of the test was to set the magnetometer in a controlled area and test to see how the earth's magnetic field altered the reading. An adjustment because of leap seconds to the satellites

timing system had to be researched. During the test, targets were placed in SOCS course to see the accuracy of the readings.

Conclusion

The research conducted at the robotics laboratory had some lasting accomplishments. The researcher got to observe how work is conducted in real-life applications of science. Various jobs needed to be done for the laboratory were completed. Field tests were performed to help complete the preparation of a robotic vehicle for use in various jobs at other military bases. The researcher learned the valuable skill of C++ programming and was able to take part in an application of it to accomplish the renovation of an mechanically controlled excavator into an autonomous remote controlled excavator.

References

Shammas, N. Teach Yourself Visual C++ 2 in 21 Days *Third Edition,* Sams Publishing,

    Indianapolis, Indiana, 1994

Waite, M. and Prata, S. The Waite Group's New C Primer Plus, Howard W. Sams & Company,

    Carmel, Indiana, 1990

APPENDIX A

Source Code to diagnostic function screen added to AOE operating program

```
#include "resource.h"

#define APSTUDIO_READONLY_SYMBOLS
/////////////////////////////////////////////////////////////////////////
//
// Generated from the TEXTINCLUDE 2 resource.
//
#include "afxres.h"


/////////////////////////////////////////////////////////////////////////
#undef APSTUDIO_READONLY_SYMBOLS



/////////////////////////////////////////////////////////////////////////
//
// Dialog
//

IDD_DIALOG1 DIALOG DISCARDABLE  0, 0, 420, 222
STYLE DS_MODALFRAME I WS_POPUP I WS_VISIBLE I WS_CAPTION I WS_SYSMENU
CAPTION "Dialog"
FONT 8, "MS Sans Serif"
BEGIN
    DEFPUSHBUTTON   "OK",IDOK,358,151,50,14
    PUSHBUTTON      "Cancel",IDCANCEL,358,170,50,14
    LTEXT           "Value",IDC_STATIC,12,4,23,9
    LTEXT           "Boom",IDC_STATIC,12,13,26,8
    LTEXT           "Stick",IDC_STATIC,12,22,20,9
    LTEXT           "Bucket",IDC_STATIC,12,30,28,9
    LTEXT           "Swing",IDC_STATIC,12,39,23,9
    LTEXT           "Ltrack",IDC_STATIC,12,47,24,9
    LTEXT           "Rtrack",IDC_STATIC,12,56,27,9
    LTEXT           "Claw",IDC_STATIC,12,65,21,9
    LTEXT           "Temperatures:",IDC_STATIC,11,90,49,9
    LTEXT           "Valve Box",IDC_STATIC,12,99,39,9
    LTEXT           "Control Box",IDC_STATIC,12,108,40,9
    LTEXT           "Cab",IDC_STATIC,12,117,21,10
    LTEXT           "HVAC",IDC_STATIC,12,126,21,10
    LTEXT           "VCU",IDC_STATIC,12,135,20,9
    LTEXT           "Outside",IDC_STATIC,12,143,29,8
    LTEXT           "Vid Box",IDC_STATIC,12,151,27,8
    LTEXT           "Vid Box Pwr",IDC_STATIC,12,159,39,8
    LTEXT           "Vid Box Aud",IDC_STATIC,12,168,41,9
    LTEXT           "Cam 2",IDC_STATIC,12,185,23,8
    LTEXT           "Cam 1",IDC_STATIC,12,176,28,8
    LTEXT           "Cam 3",IDC_STATIC,12,194,31,10
    LTEXT           "Rate",IDC_STATIC,48,4,20,9
    LTEXT           "Off",IDC_STATIC,48,13,16,9
    LTEXT           "Off",IDC_STATIC,48,22,15,9
```

```
LTEXT       "Off",IDC_STATIC,48,30,15,9
LTEXT       "Off",IDC_STATIC,48,39,13,9
LTEXT       "Off",IDC_STATIC,48,47,14,9
LTEXT       "Off",IDC_STATIC,48,56,15,9
LTEXT       "Off",IDC_STATIC,48,65,15,8
LTEXT       "no probe",IDC_STATIC,77,133,33,10
LTEXT       "no probe",IDC_STATIC,77,99,32,9
LTEXT       "no probe",IDC_STATIC,77,107,34,10
LTEXT       "no probe",IDC_STATIC,77,116,34,8
LTEXT       "no probe",IDC_STATIC,77,125,34,9
LTEXT       "no probe",IDC_STATIC,77,141,37,10
LTEXT       "no probe",IDC_STATIC,77,149,36,9
LTEXT       "no probe",IDC_STATIC,77,158,33,8
LTEXT       "no probe",IDC_STATIC,77,167,34,9
LTEXT       "no probe",IDC_STATIC,77,175,34,8
LTEXT       "no probe",IDC_STATIC,77,184,35,10
LTEXT       "no probe",IDC_STATIC,78,193,33,10
LTEXT       "Angle",IDC_STATIC,78,5,28,8
LTEXT       "0.0",IDC_STATIC,78,13,15,8
LTEXT       "0.1",IDC_STATIC,78,23,12,7
LTEXT       "0.1",IDC_STATIC,78,31,13,7
LTEXT       "0.1",IDC_STATIC,78,39,17,8
LTEXT       "0.0",IDC_STATIC,78,47,15,9
LTEXT       "0.0",IDC_STATIC,78,65,17,8
LTEXT       "0.0",IDC_STATIC,78,55,17,9
LTEXT       "0.0",IDC_STATIC,105,13,15,7
LTEXT       "0.0",IDC_STATIC,105,22,12,7
LTEXT       "0.0",IDC_STATIC,105,30,15,7
LTEXT       "Crank",IDC_STATIC,159,13,23,7
LTEXT       "Run",IDC_STATIC,159,22,19,7
LTEXT       "Estop",IDC_STATIC,159,30,22,7
LTEXT       "Range",IDC_STATIC,159,39,27,7
LTEXT       "Throttle",IDC_STATIC,159,47,27,7
LTEXT       "Alarm",IDC_STATIC,159,56,20,7
LTEXT       "Valves",IDC_STATIC,160,65,25,7
LTEXT       "Off",IDC_STATIC,201,13,14,7
CONTROL       "On",IDC_STATIC,"Static",SS_LEFTNOWORDWRAP | SS_NOPREFIX |
        WS_GROUP,201,22,13,7
LTEXT       "Off",IDC_STATIC,201,30,16,7
LTEXT       "Hi",IDC_STATIC,201,39,14,7
LTEXT       "5",IDC_STATIC,201,47,10,7
LTEXT       "Off",IDC_STATIC,201,56,15,7
LTEXT       "Off",IDC_STATIC,201,65,16,7
LTEXT       "Camera",IDC_STATIC,265,13,30,7
LTEXT       "Pan",IDC_STATIC,266,22,28,7
LTEXT       "Tilt",IDC_STATIC,266,31,17,7
LTEXT       "Focus",IDC_STATIC,266,39,23,7
LTEXT       "Zoom",IDC_STATIC,265,47,28,7
LTEXT       "Iris",IDC_STATIC,267,56,13,7
LTEXT       "1",IDC_STATIC,310,13,8,8
LTEXT       "- - -",IDC_STATIC,309,22,13,8
LTEXT       "- - -",IDC_STATIC,309,31,16,8
```

```
    LTEXT          "- - -",IDC_STATIC,309,39,15,8
    LTEXT          "- - -",IDC_STATIC,309,47,16,9
    LTEXT          "- - -",IDC_STATIC,309,56,15,9
    LTEXT          "Mode:",IDC_STATIC,134,91,22,7
    LTEXT          "Articulate -",IDC_STATIC,130,100,35,7
    LTEXT          "RUN -",IDC_STATIC,130,159,100,8
    LTEXT          "EXIT -",IDC_STATIC,130,167,109,9
END


#ifdef APSTUDIO_INVOKED
/////////////////////////////////////////////////////////////////////////
//
// TEXTINCLUDE
//

1 TEXTINCLUDE DISCARDABLE
BEGIN
    "resource.h\0"
END

2 TEXTINCLUDE DISCARDABLE
BEGIN
    "#include ""afxres.h""\r\n"
    "\0"
END

3 TEXTINCLUDE DISCARDABLE
BEGIN
    "\r\n"
    "\0"
END

/////////////////////////////////////////////////////////////////////////
#endif    // APSTUDIO_INVOKED


#ifndef APSTUDIO_INVOKED
/////////////////////////////////////////////////////////////////////////
//
// Generated from the TEXTINCLUDE 3 resource.
//


/////////////////////////////////////////////////////////////////////////
#endif    // not APSTUDIO_INVOKED
```

DETERMINATION OF SKIN:AIR PARTITION COEFFICIENTS
FOR HUMAN STRATUM CORNEUM

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Final Report for:
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DETERMINATION OF SKIN:AIR PARTITION COEFFICIENTS
FOR HUMAN STRATUM CORNEUM

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Abstract

Skin:air partition coefficients were studied for three different chemicals in relation to the human stratum corneum at three different temperatures. A target 10000 ppm concentration of dibromomethane (DBM), chloropentafluorobenzene (CPFB), and perchloroethylene (perc) vapors were separately passed over the same sample of human stratum corneum in the Thermal Gravimetric Analyzer (TGA cell). Each exposure was conducted at 27 °C, 32 °C, and 40 °C to determine the effect of temperature on the partition coefficient. It appears that higher lipophility in a chemical corresponds to increased partition coefficients. Results also indicate that the partition coefficient decreases with temperature, indicative of the significant role played by gas thermodynamics in chemical uptake by human skin. The decrease may best be modeled by an exponential decay function as opposed to a linear model, as a logarithmic transformation of the data yielded clearly linear and parallel graphs, but more data is needed to decide this conclusively.

DETERMINATION OF SKIN:AIR PARTITION COEFFICIENTS
FOR HUMAN STRATUM CORNEUM

Nafisa Islam

Introduction

Partition coefficients represent the "ratio of chemical concentration between two interfacing phases when the chemical is in equilibrium between those phases" (Jepson et al. 1). They are used in the description of physical and chemical processes in a biological system, including chemical uptake by a specified tissue. As a result, partition coefficients are essential components of physiologically based pharmacokinetic models, which simulate the movement of chemicals through a biological system over time. The skin:air partition coefficient is a measure of the tendency of the human stratum corneum, the outermost layer of human skin, to take up volatile chemicals from the air. A partition coefficient of one indicates that skin and air have an equal tendency to hold the chemical, a coefficient less than one indicates that the air has a greater tendency to hold the chemical, and a coefficient greater than one indicates that the skin has a greater tendency to take up the chemical.

Discussion of Problem

Lipophilic chemicals are taken up by the skin because the chemical binds to the lipids composing the stratum corneum. The uptake of three chemicals of varying lipophility were studied: dibromomethane (DBM), an organohalogen of relatively low lipophility, chloropentafluorobenzene (CPFB), a medium-lipophility chemical, and perchloroethylene (perc), a highly lipophilic chemical. It is hoped the behavior of these chemicals will be comparable to other chemicals of similar lipophility. For example, perchloroethylene is similar to trichloroethylene, which has caused much concern as a groundwater contaminant. The chemicals themselves are of some limited concern; DBM has some use as a chemical intermediate in industry, a chemical solvent for fats, waxes, and resins, and as an ingredient of fire-extinguishing fluids. Acute exposure to animals has caused slight irritation to the skin and eyes, and repeated exposures have caused liver and kidney damage. Perc has widespread use in dry-cleaning and is used in the vapor degreasing of metals. Inhalation causes dizziness, nausea, headaches, and other symptoms associated with depression of the central nervous system, and also irritates the eyes and skin. The partition coefficients determined may have use in a projected model of the pharmacokinetics of lipophilic chemicals in a

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human system after exposure to the chemical vapor. Therefore, exposures were conducted below, at, and above the human body temperature of 32 °C. The other chosen temperatures were 27 °C and 40 °C. Based on gas thermodynamics it was hypothesized that the partition coefficient would decrease with temperature. It was also suggested that differences in skin structure between sexes, races, and ages might influence the partition coefficient. Therefore, the same study will be repeated on skin from other donors in addition to the 46-year-old white male whose thigh skin is studied here.

Methodology

The donor skin was cut into small squares about four square centimeters in area. These were placed in petri dishes containing a solution of the enzyme trypsin in 0.05M phosphate buffered saline. The samples were incubated at 37 °C for about two hours. This facilitated the action of the trypsin to separate the stratum corneum from the inner layers of skin. Afterward, the stratum corneum was removed and placed in a solution of trypsin inhibitor in phosphate buffered saline for ten minutes to stop further action of the trypsin on the stratum corneum beyond separation. They were then placed in a water wash for 30 minutes before removing the samples to metal mesh screens and drying them. A sample of stratum corneum was then placed on a titanium plate inside the Thermal Gravimetric Analyzer (TGA cell). Dry air (zero to two percent humidity) from a compressed air tank was allowed to run continuously through the TGA cell to remove any excess water left in the sample, and to keep the sample dry.

The next step involved establishing standard curves for each of the three chemicals. A known volume of liquid chemical was injected into a bag filled with eight liters of air and volatilized by heating the bag with a blow dryer. The concentration in parts per million of chemical inside the bag would be calculated. Care was taken to make sure the standard curve included concentrations above and below the target concentration of 10000 ppm. Then 100 µL of the gas inside the bag was injected into a Hewlett-Packard HP5890 Series II Gas Chromatograph (GC). This would be repeated two to four times, and the average of the area counts given by the GC was taken. Then a graph of concentration (x-value) versus area count (y-value) was plotted, and a linear regression equation was calculated for the given data points. If the r^2 value of the regression was over 0.99, we tested the curve by again making up a known concentration of chemical vapor and injecting it into the GC. Using the regression equation, a

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computer calculated the concentration based on the area count. If the percent error of the concentration was less than five, the standard curve was considered acceptable. An example follows:

1. Standard curve calculation for DBM

Molecular weight of DBM = 173.85   Density = 2.477 g/mL

Volume of one mole at 25 °C room temperature = 24.45L

$173.85/24.45 = 7.11$ mg/m^3/ppm * 10000 ppm = 71100 mg/m^3 *1 m^3/1000 L * 8L = 569 mg

569 mg * 1 μL/2.477 mg = 230 μL DBM

So, 230 μL of DBM was needed.

$569/173.85 = 3.273$ mmol * 24.45 mL/mmol = 80 mL, $\therefore$ 7.92 L of air actually needed. The difference between 7.92 and 8 L was determined to be negligible and 8L of air was used. Based on ratio calculations, the following volumes and subsequent concentrations were used in establishment of the standard curve.

Volume of DBM	Concentration
100 μL	4348 ppm
150 μL	6522 ppm
200 μL	8696 ppm
250 μL	10870 ppm
300 μL	13044 ppm
350 μL	15217 ppm

The regression equation was $(39.9403)x - 7186.455$ with an r^2 value of 0.9977 and about 3.5 percent accuracy. The same process was repeated to establish standard curves for perc and CPFB.

The values obtained calculating the 10000 ppm concentration for an 8 L bag were multiplied by five in order to make a 10000 ppm concentration of chemical in a 40 L bag. A 40 L volume was used in order to conduct three exposures using the same bag. The concentration of the bag was tested using the GC and the standard curve to establish that it was acceptably close to 10000 ppm. The 40 L bag was made using dry air, and a 40 L dry air bag was made as well for use in removing the chemical from the stratum corneum between exposures. Both bags were kept in a tank purged of water vapor for the duration of the experiment. The temperature of the TGA cell was raised to the desired value, either 27 °C, 32 °C, or 40 °C. The first set of exposures was conducted at 27 °C. The airflow from the dry air tank was shut off and air from the dry air bag was released over the sample. Sample weight and

temperature were monitored by a realtime plot on a computer linked to the TGA. When temperature and sample weight were seen to flatline, dry air flow was shut off and air from the chemical bag. This first exposure was referred to as the first run. Due to chemical uptake, the weight of the skin sample was seen to increase on the realtime plot. When no more chemical was being taken up, stratum corneum and air were in equilibrium and the sample weight flatlined. Chemical flow was shut of and air was allowed to flow over the bag. The chemical diffused out of the skin and flowed out with the air, and the sample weight dropped back to its baseline. A second run was conducted, and then a third. This was repeated the next day at 32 °C, and on the next at 40 °C before moving on to the next chemical. Thus, three exposures were conducted for DBM, perc, and CPFB at 27 °C, 32 °C, and 40 °C.

Results

A partition coefficient was calculated for every run based on the difference in sample weight obtained by the TGA. Concentration of chemical in the skin was divided by concentration in the air as given by the average of the concentrations produced by the GC during the bag concentration check. The volume of the sample was calculated to be $2.18 * 10^{-9}$ m^3 based on a weight of 2.18 mg and a density of 1 g/cm^3. Consider, for example, the calculation of the partition coefficient for the second CPFB exposure at 27 °C:

2.208 mg – 2.094 mg = 0.114 mg/$(2.18 * 10^{-9})$ m^3 = 53669724.8 mg/m^3

10430 ppm * 8.2826 mg/m^3/ppm = 86387.5 mg/m^3

(53669724.8 mg/m^3)/(86387.5 mg/m^3) = 605

This process was repeated for each exposure at each temperature for each chemical. The following table gives each calculated partition coefficient and the averaged partition for a chemical at a given temperature.

chemical	Temp. (C)	1st run	2nd run	3rd run	average	std. dev.
Perc	27	1140	1102	1096	1112.667	23.86071
Perc	32	862	848	911.5	873.8333	33.3629
Perc	40	498	485	491	491.3333	6.506407
CPFB	27	621	605	600	608.6667	10.96966
CPFB	32	464	442	437	447.6667	14.36431
CPFB	40	285	263	269	272.3333	11.37248

Chemical						
DBM	27	208	158	158	174.6667	28.86751
DBM	32	140	133		136.5	4.949747
DBM	40	93	87	81	87	6

The standard deviation of the partition coefficients not including the average is also given in the table. See Chart 1 for a graph of the average partition coefficients with error bars based on standard deviation (Note: charts are located at the end of the report, e.g. Chart 1 is on page 14-10, Chart 2 on 14-11, etc.). For some undetermined reason the TGA software (TA 2200 TGA module) "lost" the third DBM run at 32 °C, possibly related to a power shutdown in the building that day. Note that the first DBM run at 27 °C appears unusually high compared to the two others. A trend is visible linking higher lipophility to higher partition coefficients at a set temperature. The partition coefficients clearly decrease with increase in temperature. The next table shows the linear regression analysis of these partitions with temperature.

Chemical	Run	Regression Equation	r-value
Perc	1	$y = (-49.02)x + 2451.10$	-0.99847
Perc	2	$y = (-46.78)x + 2357.376$	-0.99937
Perc	3	$y = (-47.09)x + 2387.095$	-0.99604

Standard deviation of slopes is about 1.2137.

Perc	average	$y = (-47.80)x + 2403.244$	approaching -1

CPFB	1	$y = (-25.52)x + 1298.934$	-0.99552
CPFB	2	$y = (-25.94)x + 1292.748$	-0.99445
CPFB	3	$y = (-25.05)x + 1261.868$	-0.99235

Standard deviation of slopes is about 0.4452

CPFB	average	$y = (-25.50)x + 1284.536$	-0.99419

DBM	1	$y = (-8.57)x + 429.802$	-0.97193
DBM	2	$y = (-5.49)x + 307.116$	-0.99933
DBM	3	$y = (-5.92)x + 317.923$	

Standard deviation of slopes is about 1.6680

DBM	average	$y = (-6.69)x + 353.56$	-0.99832

First DBM partition high at 27 C, see preceding table.
One data point lost in 3rd DBM run, see preceding table.
Values in this table generated by TI-82 Graphic Calculator.

It appears that the data for CPFB was the most consistent, as the standard deviation of the slopes is the least. The perc data average appears to be the most linear, but this may be influenced by a high data point during the third run at 32 °C. See Chart 3.

The thermodynamic view of partition coefficients given by Jepson et. al.., suggests that the relation between temperature and partition coefficients may be exponential in nature, so a natural logarithm transformation was done on the data; the following table summarizes the logarithmic analysis.

LN of average partitions

Run	lnPerc	lnCPFB	lnDBM
1	7.014515	6.411271	5.162879
2	6.77289	6.104049	4.916325
3	6.197123	5.607027	4.465908

Chemical	LN Linear Regression
Perc	$y = (-0.0637)x + 8.7643$
CPFB	$y = (-0.0619)x + 8.0831$
DBM	$y = (-0.0539)x + 6.6259$

Average of slopes is about -0.059833
Standard deviation of slopes is about 0.00521664.

Average Partition Exponentials

Chemical	Regression Equation	R2 value
Perc	$y = 6401.9e-0.0637x$	0.9902
CPFB	$y = 3239.4e-0.0619x$	1
DBM	$y = 754.35e-0.0539x$	0.9988

Chart 7 shows a graph of the average partition coefficients after a natural logarithm transformation. The linear regressions for each of the chemicals appear relatively parallel--the standard deviation of the slopes is about 0.005--and the regressions appear to fit well. Each r^2 value is above 0.99. The exponentiality of the DBM average is likely increased by the high partition on the first run at 27 °C, while the exponentiality of perc may be decreased due to a high point on the third run at 32 °C. See Charts 3 and 5. However, CPFB, for which the data was most consistent, appears to be exponential, with an r^2 value approaching one.

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Conclusions

Some idea has been established as to the range of skin:air partition coefficients for lipophilic chemicals. It appears that, as would be expected, the skin:air partition coefficient increases with lipophility. The average partition coefficient at 27 ° C is 1113 for perchloroethylene, 607 for CPFB, and 175 for DBM. At 32 °C they are 874, 448, and 137, respectively, and 491, 272, and 87 at 40 °C. It remains to be seen to what degree the skin:air partition coefficients vary for chemicals with lipophility similar to those studied here. Clearly in the experiment the partition coefficients decrease as temperature increases. Thermodynamically chemicals in the vapor phase have an increased tendency to remain so at higher temperatures. Regarding the mathematical modeling concepts explored, i.e. that exponential regressions may better model partition coefficients against temperature, a great deal more data is required to support these suggestions with reasonable confidence. Further experiments of this type will be conducted to determine to what extent differences in skin structure due to age, race, or sex will affect the skin:air partition coefficient.

Chart 1

Average Partition Coefficients

Error Bars Included — Standard Deviation

14-10
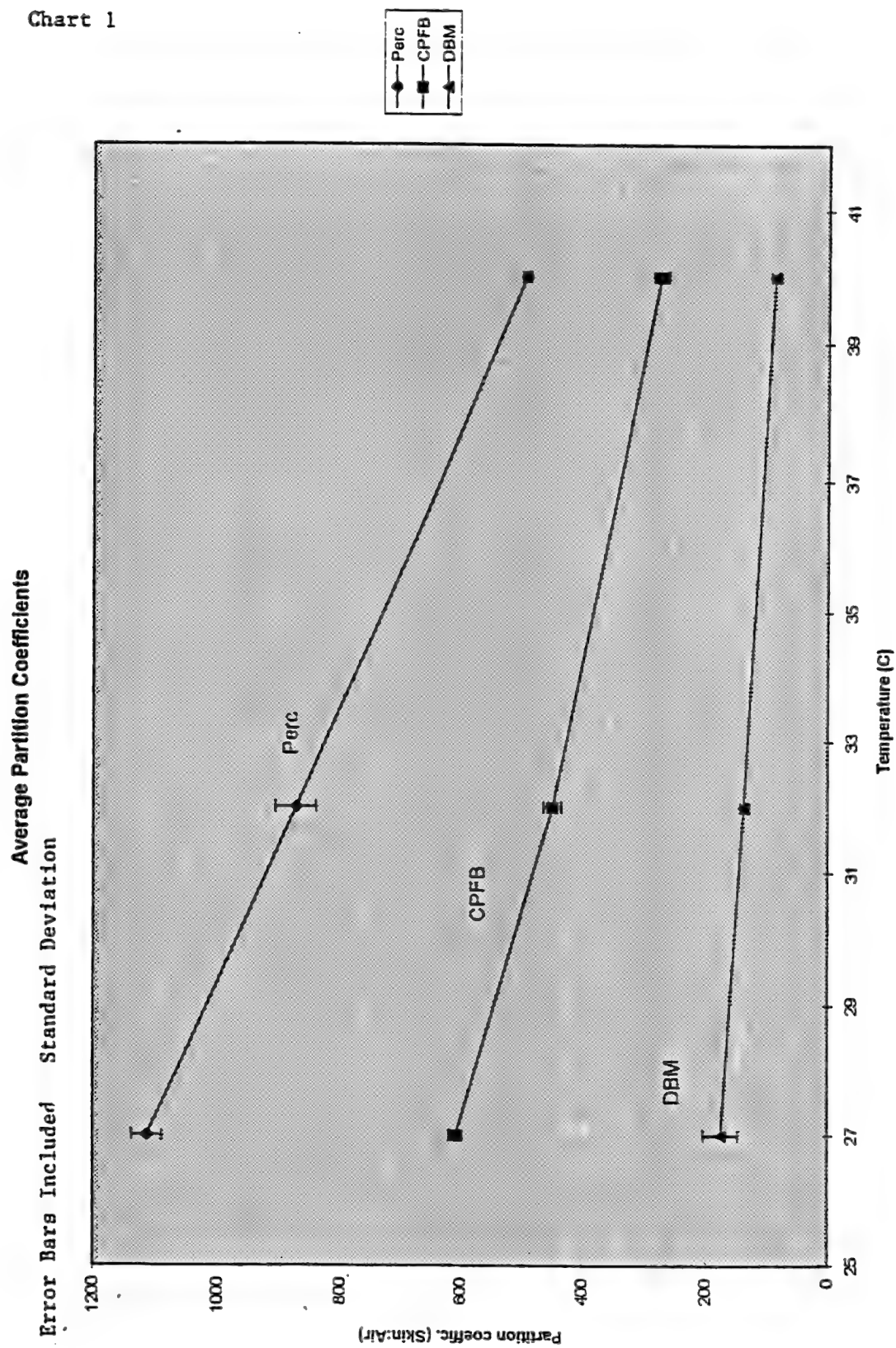
Chart 2

Average Partition Coefficient

1 Linear Regressions

$y = -47.797x + 2403.2$
$R^2 = 1$
Perc

$y = -25.504x + 1284.5$
$R^2 = 0.9884$
CPFB

$y = -6.6919x + 353.55$
$R^2 = 0.9966$ DBM

Partition Coefficient (Skin:Air)

Temperature
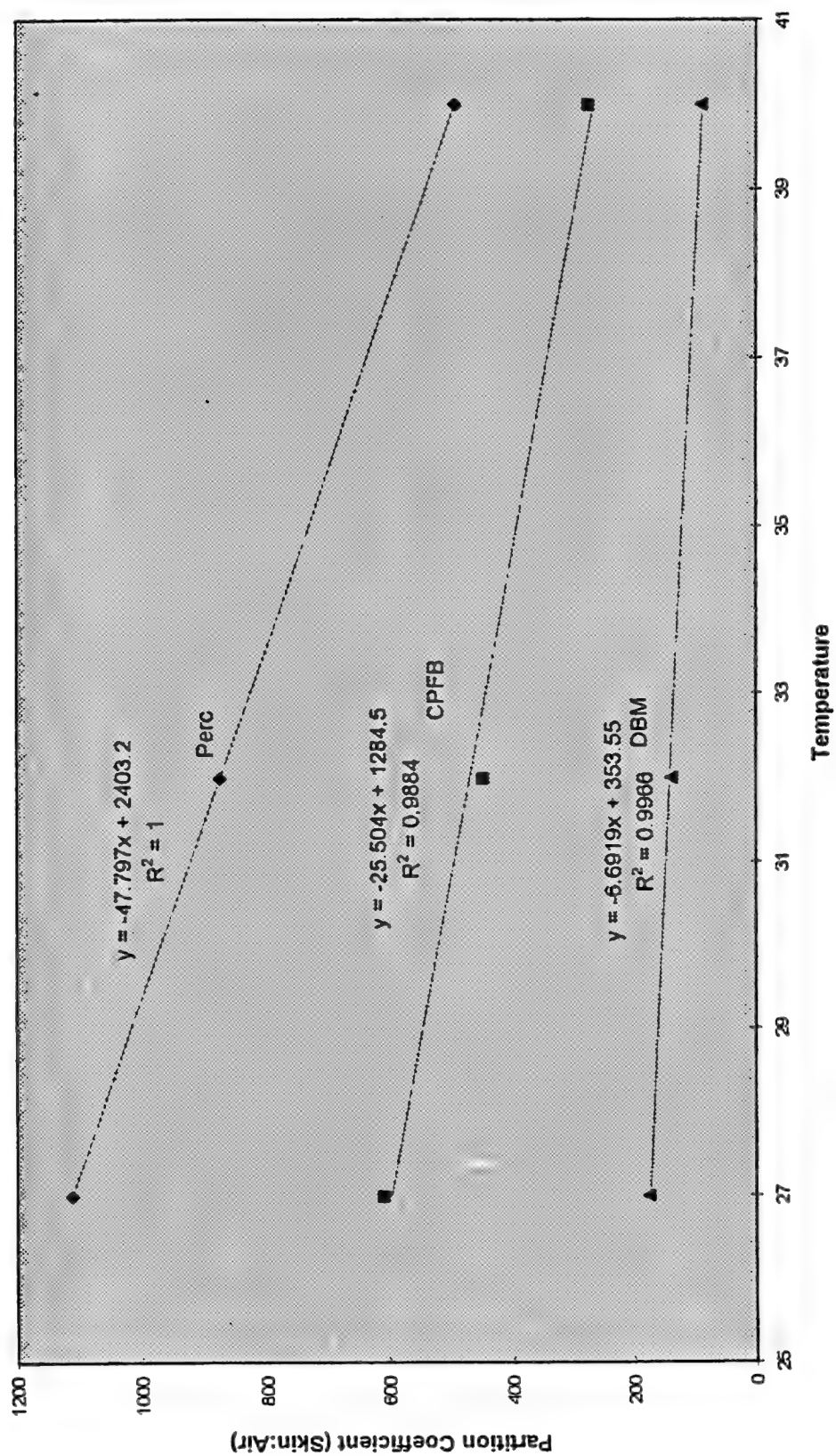
Chart 3
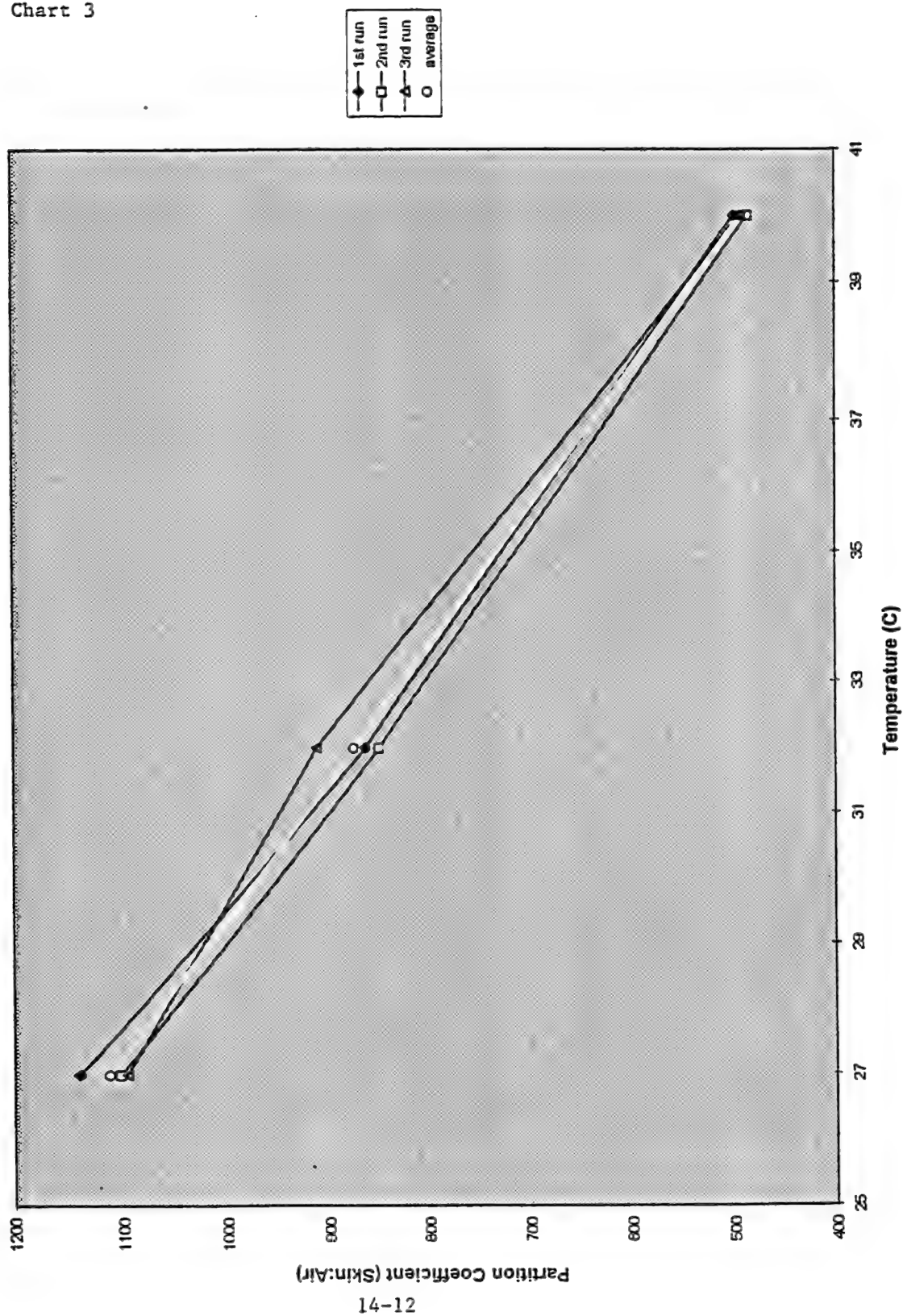
Perc Partitions

Chart 4

CPFB Partitions

Chart 5

DBM Partitions

Temperature (C)

Partition Coefficient (Skin:Air)

1st run
2nd run
3rd run
average

14-14
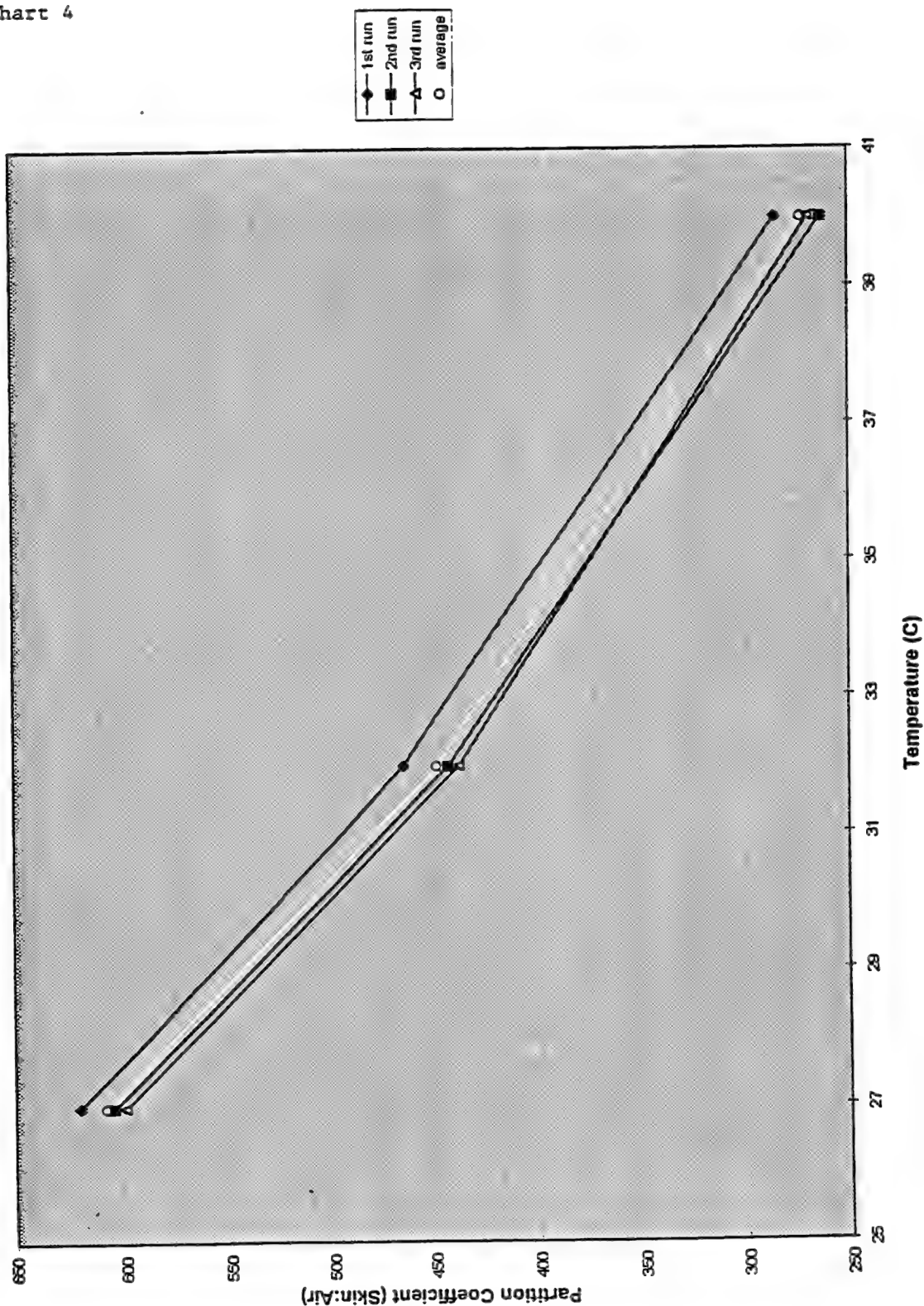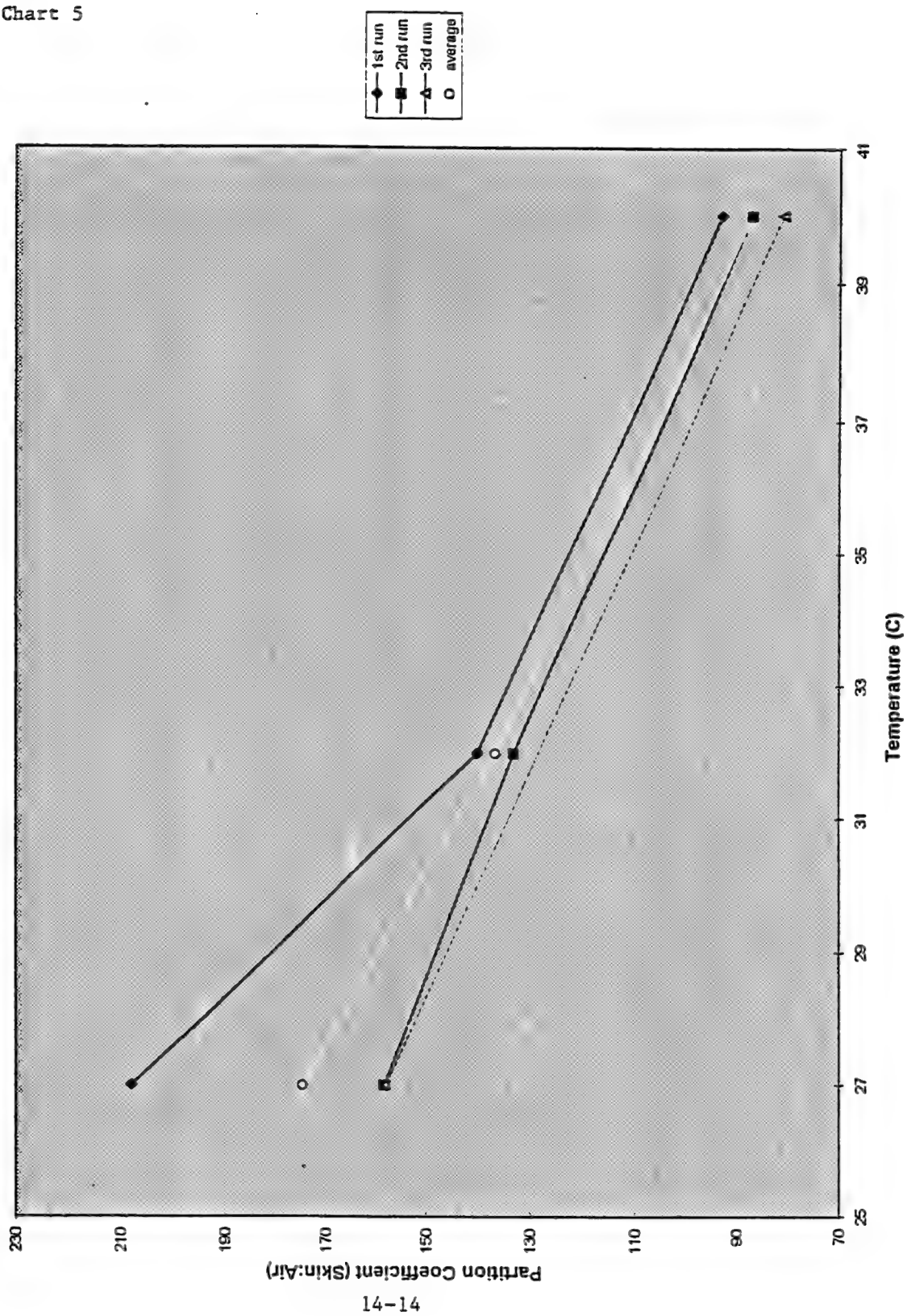
Chart 6

Average PC Exponentials

$y = 6401.9e^{-0.0637x}$
$R^2 = 0.9802$

$y = 3239.4e^{-0.0619x}$
$R^2 = 1$

$y = 754.35e^{-0.0526x}$
$R^2 = 0.9988$

Perc

CPFB

DBM

Partition Coefficient (Skin:Air)

Temperature
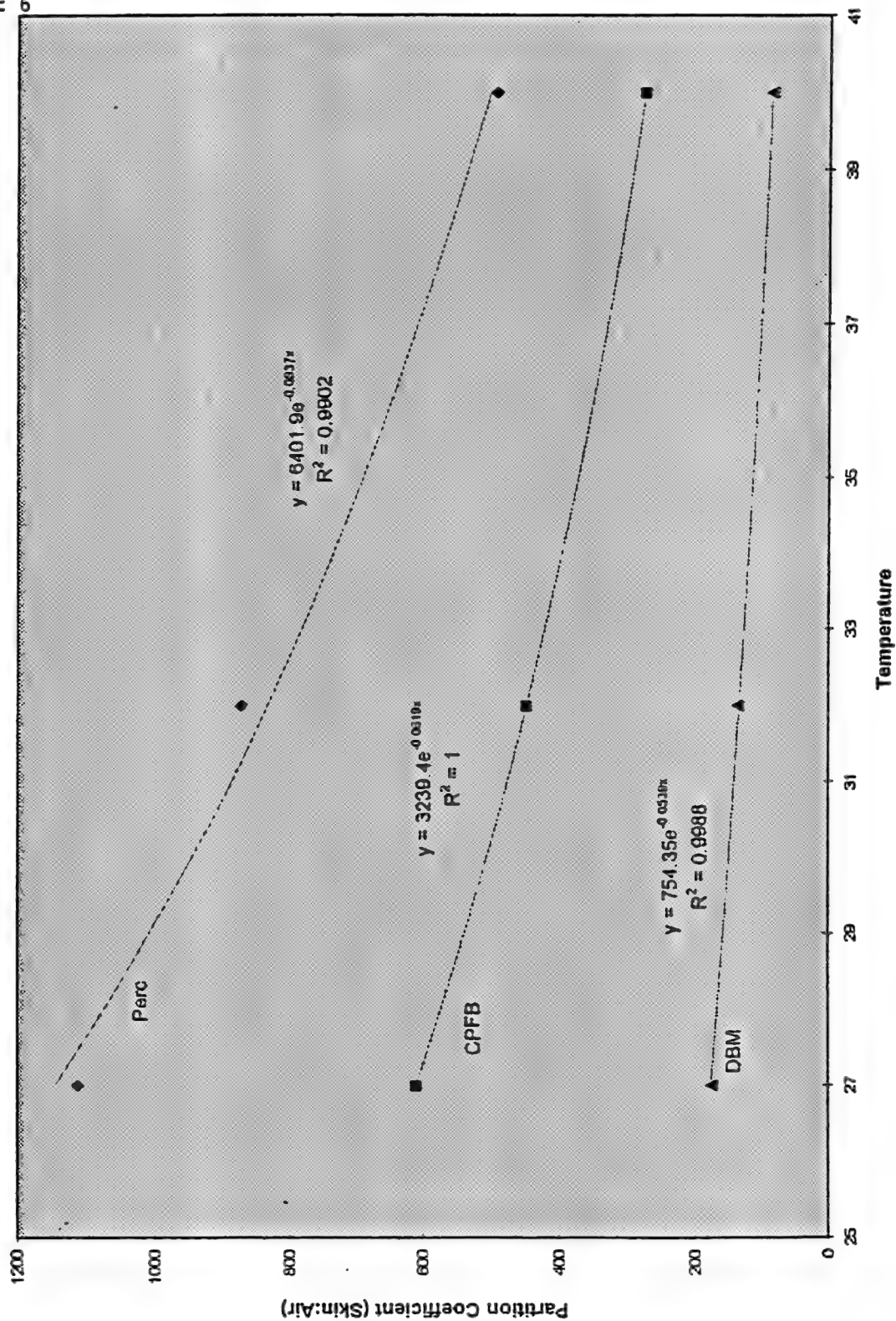
Chart 7

LN Plot of Average Partitions

y = -0.0637x + 8.7643
$R^2 = 0.9902$ Perc

y = -0.0619x + 8.0831
$R^2 = 1$ CPFB

y = -0.0539x + 6.6259
$R^2 = 0.9888$ DBM

InPartition

Temperature

14-16
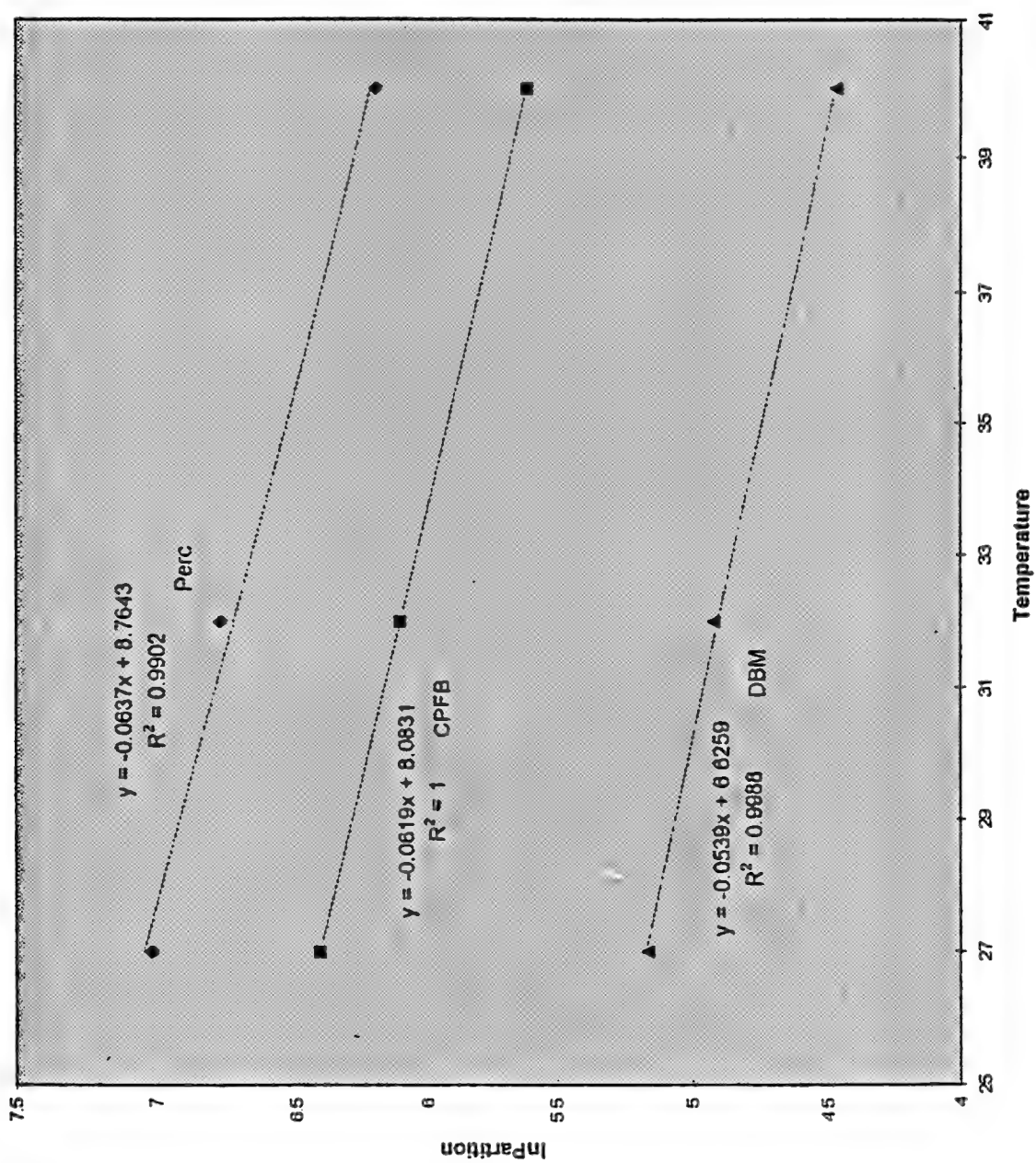
Works Cited

Jepson, Gary, et al. "A Partition Coefficient Determination Method for Nonvolatile Chemicals in Biological

Tissues." <u>Fundamental and Applied Toxicology</u> 22 (1994): 519-524.

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PSYCHOPHYSIOLOGICAL DATA: EYEBLINKS, HEART RATE, AND RESPIRATION

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PSYCHOPHYSIOLOGICAL DATA: EYEBLINKS, HEART RATE, AND RESPIRATION

Kelly M. Keish

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Abstract

Psychophysiological data involving eyeblinks, heart rate, and respiration were collected and analyzed. All data were obtained using electrodes on the surface of the skin of human subjects and collected while the subjects completed a Multi-Attribute Task Battery in a simulated environment. The data was graphed and observations were made.

PHYSCOPHYSIOLOGICAL DATA: EYEBLINKS, HEART RATE, AND RESPIRATION

Kelly M. Keish

Introduction

Psychophysiology has been dated as far back as the time of Alexander the Great, but did not become prevalent in the scientific community until the 1950s (Stern et al., 1980). Today, psychophysiological data is studied by scientists and researchers to determine workload levels of pilots, co-pilots, navigators, and boom operators during flight missions. This data can also be collected in a simulator. Three measures of psychophysiological data include heart rate, eyeblinks, and respiration. These measures along with EEG have shown differences in mental workload conditions in a multi-task situation (Wilson, Swain, Brookings, 1996). In this paper, EEG will not be included.

Problem

Mental workload levels are difficult to determine. The subjective opinion of the subject does not always correspond to his/her performance on a particular task or mission segment. For example, when a pilot is asked to rate the difficulty of a particular task, he/she might say it was easier/harder than it actually was. Psychophysiological data can be used as a measure of mental and physical workload without interrupting the pilot with subjective questions.

Methodology

The first step in collecting psychophysiological data is to apply electrodes to a clean skin surface. The electrodes measure an electrical signal already present in the body. The signal is enlarged by use of an amplifier, digitized by an A/D converter, and displayed on a computer screen. Once

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the signal is obtained successfully, recording to a computer file can begin. Data is recorded while human subjects complete the Multi-Attribute Task Battery (MATB) which presents visual monitoring, auditory, and tracking tasks to the subject (Comstock et al., 1992). There were up to eight trials for each subject that lasted approximately three minutes. These data were saved in a file on the PATS (Psychophysiological Assessment Test System). Here the data can be analyzed by command and viewed for editing. Once all the data had been analyzed on PATS, heart rate, interbeat intervals, average number of eyeblinks, and number of breaths per minute were graphed for one subject using Excel.

Results

In Figures 1-4, the psychophysiological data for one subject is graphed. It is expected that as a level of workload becomes higher, then the subject's heart rate will increase. This is illustrated in figure 1. Figure 2 illustrates the interbeat interval, the space between R waves. As a task becomes more difficult, the interbeat interval decreases, as expected. However, the number of eyeblinks are expected to decrease for harder tasks, but in figure 3, the number of eyeblinks decreases for the communication trial. The communication trial did not surpass the easy trial's number of eyeblinks as expected. Finally, figure 4 shows a trend opposite to what was expected. Instead of an increase in the breaths per minute for more difficult trials, the number decreased.

Conclusion

Analyzing psychophysiological data can ultimately help to determine workload levels and stress levels. The data can be compared with subjective and performance measures to determine the overall workload of the subject. All data collected is useful for finding new ways to complete given tasks in the given amount of time. The data can help to determine how much work a pilot can handle during a mission. Variations occur in every experiment, i.e. an increased respiration

rate when a decrease is expected, as shown in this example. The psychophysiological data can give a general idea of the effects of the workload levels on the subject without subjective feedback from the subject.

Figure 1: Mean Heartbeats/Minute
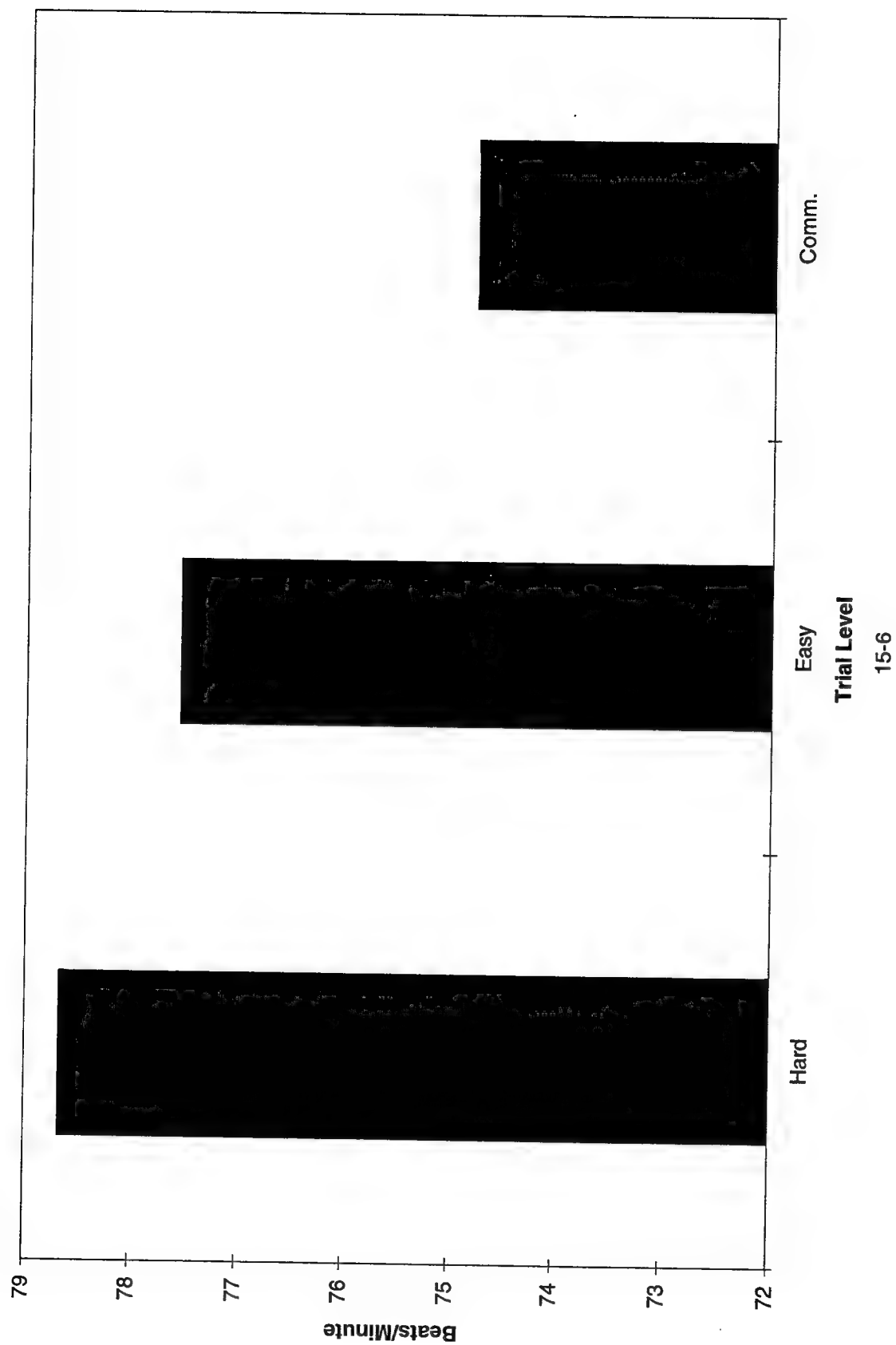
Figure 2: Mean Interbeat Intervals
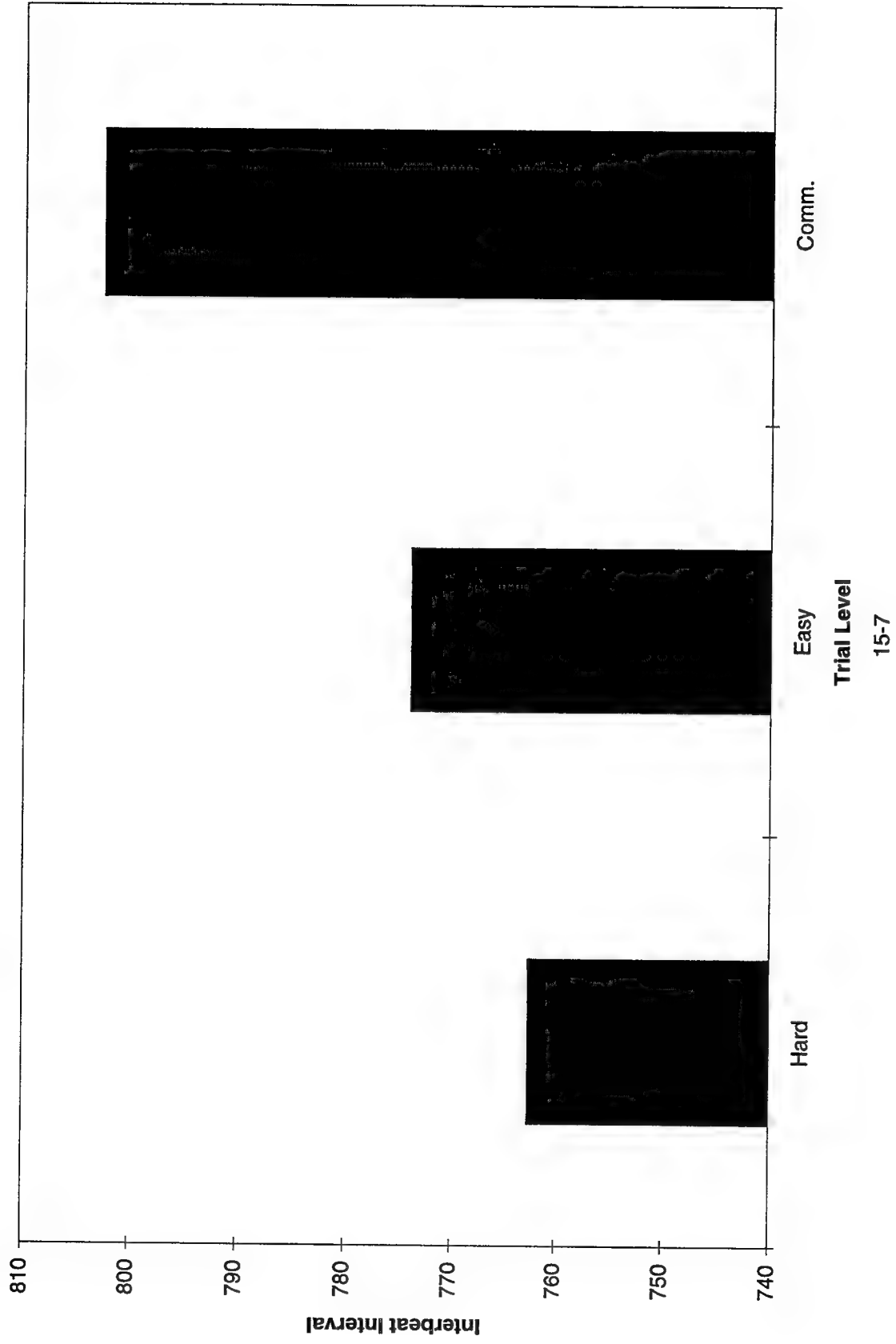
Figure 3: Mean Eyeblinks/Minute
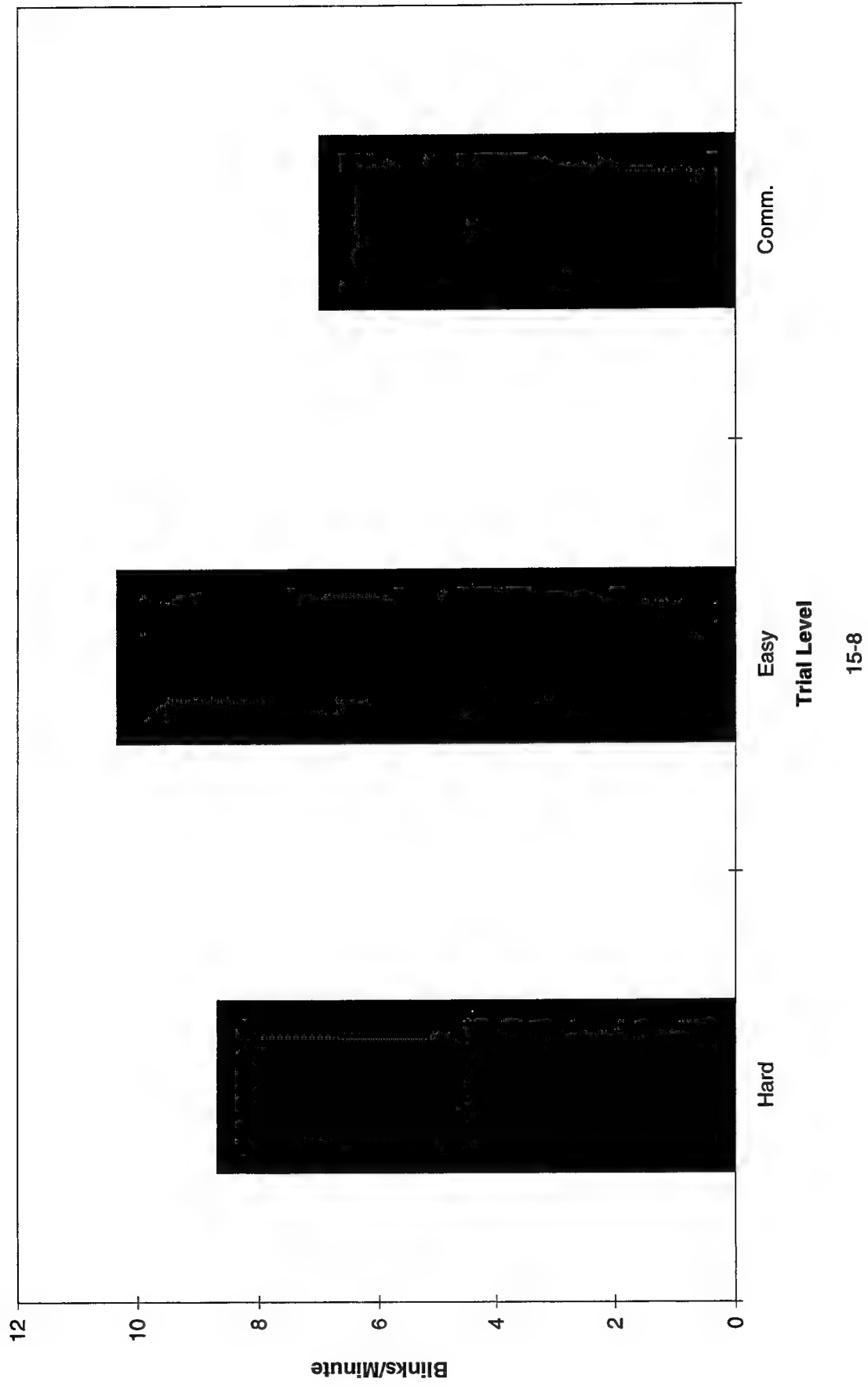
Figure 4: Breaths Per Minute
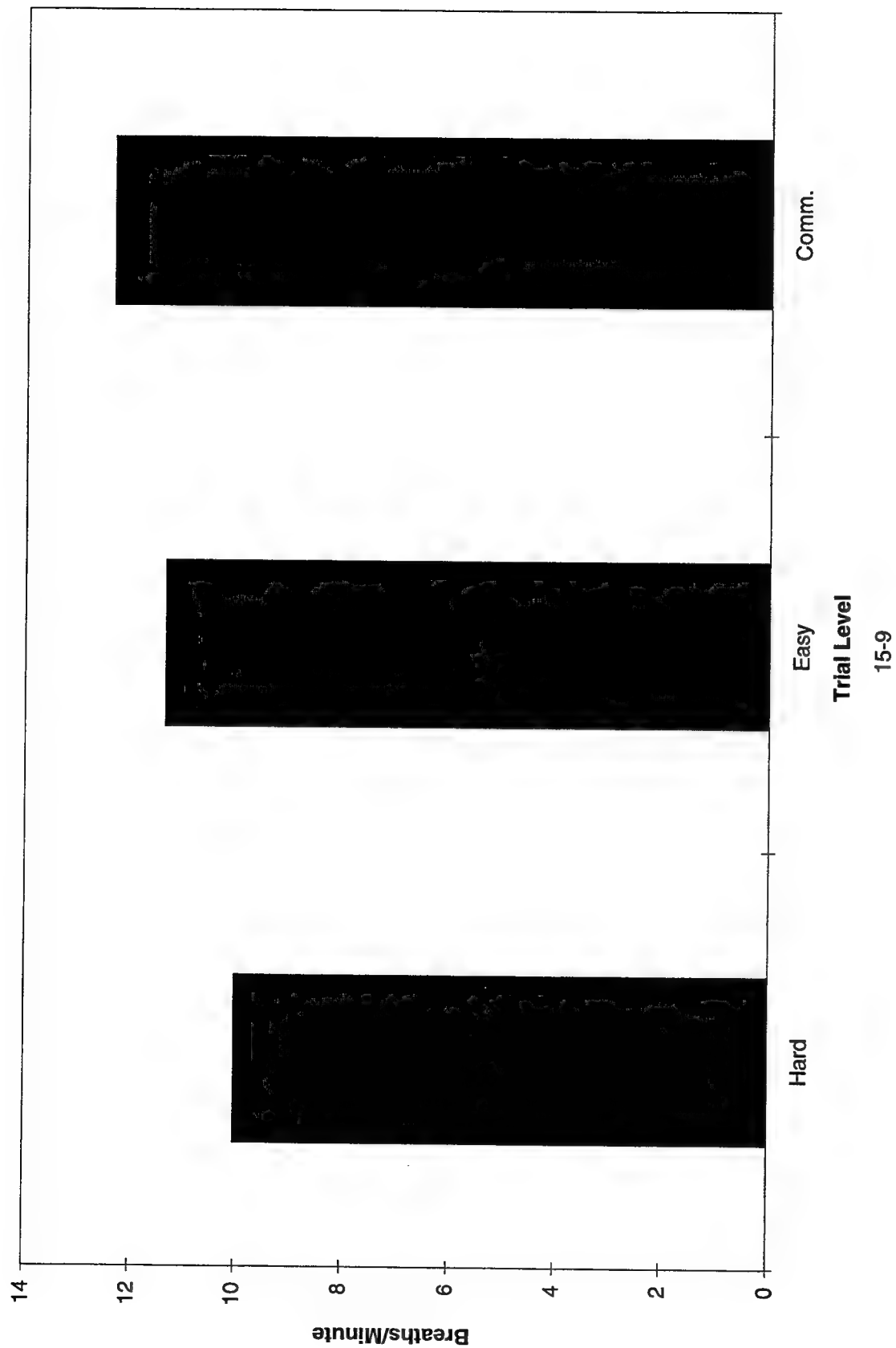
AN ANALYSIS OF OIL/GREASE IN WATER AND SOIL

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

AN ANALYSIS OF OIL/GREASE
IN WATER AND SOIL

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Abstract

An analysis of oil and grease in water and soil samples was conducted. Water samples were measured in 500 ml flask containers with an addition of freon and Sulfuric Acid. The samples were agitated by hand and by machine for 3 minutes. After this process, the samples were extracted into 10 ml cylinders. Soil samples were weighed out and freon was added. These were stirred for 2 minutes and extracted into cylinders.

Soil and water samples were investigated for pollutants. An analysis of oil and grease was conducted. Water samples wee measured in 500 ml flask containers with freon and Sulfuric Acid added. These samples were agitated by hand and by machine for 3 minutes. After this process, the samples were extracted into 10 ml cylinders. Soil samples were weighed out and freon was added. These samples were stirred for 2 minutes and extracted into cylinders.

AN ANALYSIS OF OIL/GREASE IN WATER AND SOIL

Adriana Y. Lopez

Introduction

The analysis of oil and grease in water and soil is important to any community. If water or soil contains an abnormally high content of oil and grease, it could affect an entire population with deadly results. Farmers and ranchers could suffer if their crops or cattle are subjected to these contaminants. Wildlife could be eradicated because of this environmental threat. Analysis are conducted to make certain that no water or soil supply has been tainted with pollutants. These resources could be polluted by airplane and train accidents involving hazardous materials, industrial pollution, and human carelessness.

Methodology

Water
The analysis of this resource was conducted by using freon and Sulfuric Acid. 500 ml of the sample were poured into a flask. To this, 20 ml of freon and 5 ml of Sulfuric Acid were added. This as shaken by hand to remove excess air from the sample. The flask was placed in a mixing machine for 3 minutes for additional agitation. The container was removed from the machine and placed on a rack. The water, along with the freon and the acid, was suspended as the oil and grease were filtered into a 10 ml cylinder. The sample was run through an IR machine t detect traces of any oil and grease that remained. The observations were recorded.

Soil
Freon was used in this investigation. 50 grams of soil were weighed, and 50 ml of freon were added to each sample. This was hand stirred for 2 minutes to extract the oil and grease from the soil. The sample was filtered into a 25 ml cylinder and run through an IR machine to detect any traces of contaminants in the soil. The findings wee recorded.

EVALUATION OF ALTERNATIVE CONTROL TECHNOLOGIES

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Final Report for High School Apprenticeship Program

Armstrong Laboratory

August 1996

EVALUATION OF ALTERNATIVE CONTROL TECHNOLOGIES

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Abstract

Alternative control technologies may provide interfaces preferable to the traditional manual control of modern systems. The Alternative Control Technology (ACT) Laboratory is dedicated to the research and evaluation of such nonconventional controls. Various investigations are underway at the ACT Laboratory to study control based on EEG (electroencephalograph) and eye-line-of sight. The work performed in this summer apprenticeship was in support of these projects. The tasks involved 1) manipulating and analyzing data recorded from several experiments examining brain-actuatedcontrol, 2) collecting and analyzing data using a new eye tracker system, 3) generating a more tailored user manual for that system, and 4) creating a database of potential customers for alternative control technology.

EVALUATION OF ALTERNATIVE CONTROL TECHNOLOGIES

Darby Mahan

Introduction

The work performed in the course of this apprenticeship was done in support of the projects underway in the Alternative Control Technology (ACT) Laboratory of the Human Engineering Division, Armstrong Laboratory, Wright-Patterson Air Force Base. The purpose of this laboratory is to evaluate nonconventional human-computer interfaces. The ultimate goal of these interfaces is to reduce manual workload in Air Force systems. A prime example of the need for these developments is the burden placed on the overtaxed pilot in modern-day fighter cockpits. The new systems will provide an alternate form of control for the numerous secondary tasks, therefore hopefully relieving some of the load.

These novel control interfaces not only have military implications, but also provide hope for improved communication between users and systems in general. In the area of rehabilitation, alternative controls could offer the means of increased autonomy for those who cannot utilize traditional manual controls. Alternative controls presently being employed and researched cover a broad spectrum of disciplines. Some already in use include sip-puff tubes, chin operated joysticks, voice control, head tracking, and eye-line-of sight control. Methods still in the preliminary stages of development include EMG (electromyographic)-based control and EEG (electroencephalographic)-based control.

Objective

The various investigations conducted in the ACT Laboratory require support and assistance in numerous ways. The work performed during this summer apprenticeship was supplementary to the projects conducted on EEG-based control and eye-line-of sight control.

EEG-Based Control Research

Background

EEG-based control offers great potential as an alternative control. It is the first medium through which we may be able to operate a system or communicate with absolutely no physical movement or control. The applications for this approach are endless. In industry, brain-actuatedcontrol could allow a worker to direct a task without

removing his/her hands from a necessary operation. In rehabilitation, persons with debilitating diseases could use EEG-based control as a means of communication when their nervous systems no longer afford them traditional means of interaction.

While some EEG-based applications are already in the preliminary stages of use, most work involving EEG-based control is still in the research and developmental stages. It is a relatively new field in the area of alternative controls due to the fact that it requires instruments only recently developed. Foremost among these is a signal processor that is able to track a brain wave of only a few microvolts in amplitude. Recorded with electrodes at selected scalp sites, such signals can be singled out and translated into a mechanism for control.

The type of signal used to mediate control separates EEG-based control research into a couple of different areas. One discipline, mainly addressed by Gert Pfurtscheller and his colleagues at the Graz University in Austria, involves pattern recognition algorithms [1, 2]. The algorithms are developed to recognize EEG characteristics that appear before specified physical movements. The aim of this research is to accurately predict motion through interpretation of EEG signals alone. Another major path of research entails training subjects to self-regulate an EEG response [3]. Jonathan Wolpaw and his colleagues at the Wadsworth Center for Laboratories and Research in New York conduct investigations utilizing control of the 8-12 Hz "mu" rhythm to control cursor movement on a computer screen [4, 5]. Recording of baseline brain waves is performed beforehand to identify an individual's mu rhythm. During the following trials, the subject controls the cursor by manipulating amplitude of that rhythm. An alternate approach to EEG self-regulation is represented by the research done at the ACT Laboratory at Wright-Patterson Air Force Base. Regulation of a steady-state evoked response is used to perform the tasks being utilized [6]. Some of these investigations are described below, along with a summary of the support provided during this reporting period.

Experiment 1: Exploring the Use of EEG-Based Control in a Color Matching Task

In this task, a steady-state visual evoked response (SSVER) was produced in the visual cortex by fluorescent lights modulated in intensity at 13.25 times/second (13.25 Hz). The controlling signal was the magnitude of the SSVER, recorded across the O1 and O2 occipital electrode sites (positions on the left and right visual cortical hemispheres) [7].

The goal was to change the fill color of the displayed square to match the border color. It was necessary to perform at least two color steps in a row. The steps were

performed by suppressions (for blue matches) or enhancements (for red matches) of the subject's SSVER [6]. The modulations had to be sustained for a period of two seconds in order for a color step to occur. Both objective performance scores and subjective data were collected during the experiment.

Support Provided

1. At the end of the experiment, each subject was given a questionnaire of 16 inquiries to evaluate how he/she learned and achieved the brain-actuated control. It contained short answer questions and fill-in charts concerning techniques, performance, ability, and comparison of evoking versus suppressing the brain response. Answers to the rating questions were tallied using Word™ Word Processing Program, Version 6.0. The responses were compiled so that the information from all subjects is presented after the corresponding question.

2. The results of the above questionnaire were summarized across all subjects. While insufficient data was collected to conduct statistical analyses, the data was examined to detect trends in the responses. Focusing on specific areas of the display was a common technique employed to attain a color match. The degree of concentration needed to achieve the color match varied greatly between subjects. Ratings comparing the difficulty of learning, initiating, sustaining, and stopping an evoked response versus a suppressed response also varied. Results show that the subjects always found one of the two processes to be harder. Which one, however, altered on an individual basis.

These results as well as the compilation of responses to the questionnaire will be included in a report currently under preparation that will document the entire study.

Experiment 2: Exploring the Use of EEG-Based Control for Switch Selection

The mechanism of control for this experiment is the same as that used in the color matching task. The display for this task consists of three squares, or switches, lined up vertically next to three corresponding rectangular areas, or target fields. To cycle through the switches, a subject must enhance his/her SSVER to threshold until the border of the next switch up turns green. Then he/she must maintain the SSVER above threshold for 1.5 seconds until the inside fills with green. Once totally filled, the entire square will turn red and the above switch begins to fill. The switches always cycle up, wrapping around from top to bottom. To stop the cycling, the SSVER must be suppressed below threshold level.

The targets, represented by small red dots, appear one at a time in a randomly selected target field. They will remain there for ten seconds or until destroyed. To acquire a "hit," the SSVER must be enhanced until the switch next to the target-

containing target field is selected. The subject must then suppress his/her SSVER to stop the cycling of switches and hit the joystick trigger to destroy the target [6].

One subject session consists of 12 sets of 18 targets and lasts about 45 minutes total. Subjects get feedback on the magnitude of their SSVER by watching the changes in the switch border and fill color during switch section. Half of the subjects are given additional feedback on the real-time magnitude of their SSVER in the form of a feedback bar. After 21 training sessions, there is then one test session to measure baseline performance and collect eye gaze measurements using EOG (electroocculogram) signals. This is followed by five additional sessions with the alternate feedback condition.

Support Provided

1. After each session, the average number of targets acquired across all sets for that day was calculated. Using the Microsoft EXCEL™ Spreadsheet, these numbers were changed to percentages and graphed as a function of session number for each subject to display a learning curve. The eight subjects were separated into those who originally received the additional feedback bar and those who did not. Each subject's curve was split into two different graphs: one representing the first 21 training sessions with one feedback condition and one representing the 5 sessions with the alternate feedback condition.

Since data collection is still underway, step-by-step instructions were generated on how to add data collected after this reporting period.

While some subjects show better results than others, all are showing a learning curve. For example, Subject 9 obtained scores of 45, 53, 77, and 84 percent in the first four sessions. Subject 4's scores, however, fluctuated in the 30 to 40 percent range for twelve sessions before showing a gradual improvement. As this study is still in progress, there is not yet enough data to speculate on the effects of the feedback condition on the rate of learning.

2. Each subject filled out a standardized NASA Task Load Index Questionnaire rating sheet after every session to assess demand that each of six parameters had on them that day. These parameters include mental demand, physical demand, temporal demand, performance, effort, and frustration. The responses were given numerical values for subsequent analysis. Overall, as the subjects became more comfortable with the task, the physical and temporal demands as well as effort and frustration ratings went down. Conversely, the performance ratings went up. After the last session, the subjects filled out a task load index that compared the six parameters, two at a time, in fifteen different combinations. The number of times a factor was selected (the weight) was tabulated and entered onto the same spreadsheet as the ratings sheet responses. Spreadsheet features

were used to calculate the weighted ratings and the overall workload score as stipulated by the NASA-TLX Package (v. 1.0) issued by NASA Ames Research Center. The former calculation is the product of the raw ratings and the weight and the latter is the sum of all the weighted ratings divided by 15 (the sum of the weights). To date, only two subjects have completed this questionnaire, rendering comparison of the overall workload scores premature.

Subjects also completed a 23-question questionnaire very similar to the one described in the color-matching experiment, only this one was tailored to the weapons task instead. Once again, the responses were compiled so that all subject feedback is available in one document.

3. In support of the analysis of the questionnaire data collected, a spreadsheet template for the NASA Task Load Index Questionnaire was created using Microsoft EXCEL, Version 5.0. The format and the functions entered are the same as those used in recording subject responses to the NASA-TLX Questionnaire and then in calculating the weighted ratings and overall workload score. General instructions were created to facilitate future use of the template.

Experiment 3: Exploring Feasibility of Using an Audio or Tactile Stimulus to Create an Evoked Response Suitable for Application With an EEG-Based Control System

The stimulus presently used for creating a steady-state evoked response for EEG-based control is a light modulating in intensity at a frequency of 13.25 times per second. This flickering illumination can be somewhat distracting, not to mention the fact that it requires the task to be carried out in dimly-lit environment with a constant illumination level. This situation is not practical for real-world application. Research is currently underway to determine if tactile or audio stimuli can produce an evoked response in the brain suitable for use in EEG-based control systems. Either one of these stimuli could prove to be a feasible alternative to the light. Preliminary runs were conducted with one subject only; several frequencies of both auditory and tactile stimuli were examined. Electrical brain activity on the scalp was recorded with a nylon multichannel electrode cap. The data was recorded at various frequencies with a Bio-logic Brain Atlas™ System.

Support Provided

Fast Fourier transforms (FFT's) were to be performed to determine which frequencies and electrode sites of the two stimuli yielded promising evoked responses. In preparation for the data stream analyses, a laborious data screening procedure was

performed. Sections containing eye blinks were removed and the rest of the data was banked and averaged. The files included two audio runs at 13 Hz and one run each at 23 and 40 Hz. The tactile runs covered the same number of runs at the same frequencies. Each run contained up to 84 banks. Each bank had to be set at the initialization of the stimulus and, once positioned, covered a period of about 1.33 seconds. The numbered banks were then converted to letter files (A-Z) and averaged in sets of up to 26. Those averaged files are now available for subsequent analysis with FFT.

Eye Line-of-Sight Control Research

Background

Control using eye line-of-sight (LOS) is a much more developed technology than brain-actuated control. Early studies date back to the late 1970's. LOS technologies, combining head and eye tracking systems, have already been implemented in flight simulators.

There are a number of different ways in which LOS can be tracked for control. Head-tracking can be done using magnetic, ultrasonic, and electro-optical technologies. Magnetic trackers are particularly effective because they need only one transmitter and receiver and can produce accurate measurements over a wide range of head locations [3]. The actual eye tracking can be done in a number of ways. In one technique, EOG potential between the front and the back of the eye can be measured to represent the optical axis. The better methods, however, involve video tracking of certain parts of the eye for position. The limbus, pupil, lower eyelid, first Purkinje image (corneal reflection), or the fourth Purkinje image (lens reflection) can be tracked. Rotation and translation can both be tracked using the relative positions of the pupil center and corneal reflection or the corneal reflection and the fourth Purkinje image. The two-feature eye trackers prove to be the most effectual and accurate.

The ACT Laboratory currently uses an ISCAN™ eye-LOS tracking system. The system consists of a helmet-mounted infrared light source, eye imaging system, and is designed to be interfaced to a Polhemus magnetic head tracker. It was recently upgraded to a PC version and the ACT lab is in the process of implementing it. Prepatory runs are being performed with use of an artificial eye setup (using a gimbal mounted contact lens) called Arteye to evaluate drift, etc.

Support Provided

1. The manual provided with the newly updated ISCAN system was not well organized or clearly worded. Procedures in the laboratory are limited due to the unavailability of a

head tracker at this point in time. A simplified user manual was created describing steps to be taken in light of the limited procedures. This new document also explains clearly all menu selections.

2. Before tests were conducted on the Arteye to assess drift, etc., there were investigations done to assess the effect of changing the position of the infrared light source, the threshold on the eye imaging system, and the position of the Arteye itself.

To study the effect of the light position, six trials of five runs each were performed at the (horizontal, vertical) position (0, 0); half of the trials were run with the light source slightly to the left of the Arteye and half were run with the light source directed into the middle of the Arteye. The measurements recorded represent pixel positions on the screen. Changes in the pixel positions result in a perceived change of eye position. The standard deviation of pixel measurements of the runs differed by 50% in the second half of the trials. It was concluded that the position of the infrared light source must remain the same on all measurements to ensure comparability of data.

The light source and threshold were then adjusted to settings suitable for the (horizontal, vertical) position (0, 0). One set of five continuous runs was executed at each of eight positions [(0, 20), (0,10), (0, -10), (0, -20), (20, 0), (10, 0), (-10, 0), and (-20, 0)], changing only threshold levels, to determine if the light source would have to be adjusted for future runs at that site. The factor examined was the acceptability of the standard deviations of measurements for the set (0 was optimal while anything above 1.0 was considered too large). The only sites to register unacceptable standard deviations were (0, 10) and (0, 20). Deviation on (0, 10) reached a level near 51 times that of other positions, and the levels increased in (0, 20). These are the sites at which the light source must be readjusted to a better angle for future tasks.

It has not been determined if the variances found are large enough to prevent comparison of data for one person in one session. It does, however, seem unlikely that the positions and measurements can be accurately reproduced by another individual.

Rehabilitation Applications and Contacts

Alternative controls in general as well EEG-based control have great potential as alternative devices for persons with limiting disabilities such as severe neuromuscular disease, spinal cord injury, etc. The systems could allow these people to control computers, prosthetic limbs, wheelchairs, and home systems [7]. Individuals suffering from paralysis could gain direct mental control over their muscles through a functional electrical stimulation mechanism regulated by brain-actuated control [8].

Support Provided

Although much research and development is still required for the maturation of brain-actuated control, the utilization of EEG-based systems in rehabilitation could be realized within a five year period. In light of this, a review of businesses, institutions, and foundations concerned with rehabilitation was conducted to produce a list of potential consumers of EEG-based control. Searches were conducted with various search engines through the Internet server Netscape 2.0. A list was collated from numerous matches to rehabilitation and alternative control technology found in several search engines. The name, summary of goal or products, address, telephone, e-mail address, and web site address for each organization was recorded and entered into a database created in Microsoft EXCEL™. Attached was a copy of the home page of each organization. This information will be used by Armstrong Laboratory in their efforts to learn more about application issues and to contact potential consumers.

Conclusions

The area of research known as alternative control technology is working to produce viable alternatives to traditional manual control. These new modes of interaction can provide improved communication between user and system and control that is much more appropriate in some situations where it is either impossible or inconvenient to use the hands. Studies underway on electroencephalographic (EEG)-based control prove it to be a legitimate form of control. Some EEG-based control experiments use modulation of a steady-state evoked response (SSVER) for control. While light is primarily used to produce the SSVER, there is a possibility that a tactile or audio stimulus could fill that place.

Eye-LOS control is another field of alternative control technology. Already used in some flight simulators, it combines measure of head position and eye position using magnetic head trackers and video eye tracking. Assesments performed to investigate repeatability of results on runs done with an artificial eye setup conclude that it is unlikely that measurements taken in different sessions can prove comparable unless exacting measures are taken to prevent any slight change in the system.

Advances in the ACT areas are very promising for future industries and have great promise of moving into the mainstream. Armstrong Laboratory, in anticipation of this, has readying itself by finding potential contacts in many organizations.

References

[1] Pfurtscheller, G., Flotzinger, D., Mohl, W., & Peltoranta, M. (1992). Prediction of the side of hand movements from single-trial multi-channel EEG data using neural networks. Electroencephalography and Clinical Neurophysiology, 82, 313-315.

[2] Pfurtscheller, G., Flotzinger, D., & Neuper, C. (1994). Differentiation between finger, toe and tongue movement in man based on 40 Hz EEG. Electroencephalography and Clinical Neurophysiology, 90, 456-460.

[3] McMillan, G.R., Eggleston, R.G., & Anderson, T.R. (in press). Nonconventional controls. In G. Salvendy (Ed.), Handbook of human factors and ergonomics (2nd ed.). New York: John Wiley & Sons.

[4] Wolpaw, J.R., & McFarland, D.J. (1994). Multichannel EEG-based brain-computer communication. Electroencephalography and Clinical Neurophysiology, 90, 444-449.

[5] Wolpaw, J.R., McFarland, D.J., Neat, G.W., & Forneris, C.A. (1991). An EEG-based brain-computer interface for cursor control. Electroencephalography and Clinical Neurophysiology, 78, 252-259.
[6] Calhoun, G.L., & McMillan, G.R. (1996). EEG-based control for human-computer interaction. To be Presented at the 3rd Annual Symposium on Human Interaction with Complex Systems, August 25-28, 1996, Dayton, OH.

[7] McMillan, G.R., Calhoun, G.L., Middendorf, M.S., Schnurer, J.H., Ingle, D.F., & Nasman, V.T. (1995). Direct brain interface utilizing self-regulation of the steady state visual evoked response. Proceedings of the RESNA 18th Annual Conference (RESNA), 693-695.

[8] Calhoun, G.L., McMillan, G.R., Morton, P.E., Middendorf, M.S., Schnurer, J.H., Ingle, D.F., Glaser, R.M., & Figoni, S.F. (1995). Functional electrical stimulator control with a direct brain interface. Proceedings of the RESNA 18th Annual Conference (RESNA), 696-698.

Application of World Wide Web Technologies to Enhance Information Visualization

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Abstract

The vast growth in capability of World Wide Web technology has brought a new way of communicating and sharing information into many offices. The Logistics Research Division of Armstrong Laboratory is exploring the option of using these technologies in logistics efforts. In order to assist in this endeavor, this project was designed to produce an example of the many capabilities of applying Virtual Reality Modeling Language (VRML) and HyperText Markup Language (HTML) to logistics. In this project, VRML worlds and HTML pages were created and connected to each other. A variety of aspects of the two languages were introduced. As the project developed, some problems were encountered. Among these were response time, file size, and product problems. Some had solutions while others may be fixed at a later time when solutions are discovered. In an effort to relate this project to logistics efforts, some examples were offered for further enhancement including aircraft maintenance manuals and training. Overall, this project was a success and can be used to learn about the many possibilities of using VRML and HTML in logistics.

APPLICATION OF WORLD WIDE WEB TECHNOLOGIES TO ENHANCE INFORMATION VISUALIZATION

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Introduction

In the past few years the world has seen an explosion in the capability of technology to serve as a communication and information sharing device. The ability to clearly communicate with almost anyone in the world is becoming better and faster every day. Information on every subject under the sun can be found using the technology available. With this vast treasure of information and communication available, it would be unwise for Armstrong Laboratory's Logistics Research Division (AL/HRG) to ignore the possibilities that are present through technology. This project intends to take a basic look at the benefits that can be derived from research and participation in this new and ever expanding field.

The piece of technology greatly responsible for bringing this explosion of communication to the general public is the World Wide Web. The World Wide Web (WWW or Web) is a hypertext based application that displays information formatted in HyperText Markup Language (HTML). This information is shared with the world through servers that access the information based on its Universal Reference Locator (URL). Every site or linked set of documents has a unique URL that allows anyone in the world connected to a server to access endless information. Images, video, sound, interactive conversations, and text documents are all available for use on the Web. One can even contribute to this mountain of information by creating HTML documents or home pages.

While most of the information accessible through the WWW is two dimensional, three dimensional sites are increasing in number daily. These three dimensional sites are called worlds and are created using Virtual Reality Modeling Language (VRML). One can walk through these three dimensional sites. Objects in these worlds may serve as links to HTML sites or other VRML worlds. These virtual worlds allow information to be presented in a way more familiar to humans. As information is displayed in three dimensions, organization and relationships are often understood easier since the information more closely resembles real-world objects.

Both HTML and VRML are relatively new languages and are constantly undergoing revisions and changes. HTML version 3.0 is currently supported by Netscape among others. The improvements made in HTML 3.0 include to ability to make text blink, change text color and size in the middle of the document, and to frame information into different sections. VRML version 2.0 is set to debut in the fall of 1996. Currently, few VRML viewers support VRML 2.0, but conversion software is popping up on the Web. Additions set to appear in VRML 2.0 are animation nodes, the ability to change the sky color, sound and video links, and collision detection for objects.

As mentioned previously, an internet browser is needed to view and access information on the Web. The three main browsers available for use are Mosaic, Microsoft Internet Explorer, and Netscape. While Mosaic was most widely used in the beginning, Netscape and Internet Explorer are now more popular as Web browsers. Their ability to support HTML 3.0 advancements and VRML in one application, which Mosaic cannot currently do, gives them the edge. Due to its advanced support of VRML extensions, Netscape was chosen for use in this project. While learning HTML and VRML, Netscape proved a great help. The option to view the document source file allows one to view the page or world side by side with the HTML or VRML the author wrote. Pairing up new or unfamiliar elements on pages or in worlds with their written counterpart using this tool saves the time of experimenting to achieve the same look in new pages or worlds.

Purpose

As the popularity of the Web increases, the various Web technologies are being applied in different areas. Armstrong Laboratory's Logistics Research Division (AL/HRG) is investigating the use of VRML and HTML in logistics applications. AL/HRG's mission includes finding more effective and efficient ways to display and enhance information to assist Air Force logistics personnel. VRML and HTML provide a new method of producing and presenting information, therefore offering another option for those who work in logistics. The ease with which information can be accessed and relationships between information understood can strengthen many people's work

environments. The division is also building an intranet and WWW home page for distributing research information. These two efforts were combined in this project which hopes to produce information helpful to both.

The objective of this summer research was to investigate, design, and develop an office intranet to show the capabilities of VRML and HTML. By demonstrating these capabilities in a small effort, division personnel were introduced to the benefits of these new technologies for possible application in existing and future logistics research efforts.

Methodology

To write a novel in English, one must first know the English language. The same is true for this project. To convey information in 2 or 3 dimensions on the World Wide Web, one must be fluent in the formatting languages of HTML and VRML. There are many ways to become proficient in a subject, trial-and-error and guided tutorials among them. In this case both mentioned methods came into use. Surfing the Web with little direction or aim allowed a first look at the medium at hand. Learning the basics of how to write and achieve elements came by reading on-line tutorials and reference pages. Trial and error followed as experimental pages and worlds came to life. Construction of simple pages utilizing several different elements such as tables, images, and frames and worlds using primitive shapes along with indexed face sets gave control of the learned elements. Once fluent, or at least proficient, in HTML and VRML, work on the project could begin.

The three dimensional model of the building was created first. A floor plan of the building aided in beginning the construction of the basic building structure. A checked and revised plan with a new scale and moveable walls added served as the blueprint for the virtual world. Walking through the building many times provided a reference as to what a virtual walk through should look like. The partner approach to this project dictated that each aspect of the building be made separately. This approach also helped keep file sizes manageable. While each floor was created in a separate file, the same basic procedure was used to create each floor. The permanent outside walls were constructed first, followed by the permanent walls inside. The moveable walls, or

cubicles, were created next. These walls were not placed exactly because they may be moved at any time. Setting them up in a simpler layout than they actually are allowed for increased navigation ease. All walls were constructed using transformed cubes, not indexed faces. This method was chosen because of the ease of using cubes. Most browsers also optimize cubes because they know how to deal with them. Using cubes meant that the door headers had to be added separately from the rest of the walls. This was the next step. While door headers were added, doors were not. This was done to allow easier viewing and navigation into rooms. During the process of placing the walls, the ceiling was omitted so that the position of the walls could be seen from the top. This gave a floor plan view of the world and made for easy comparison to the blueprint.

Once the walls had been installed in the building, the windows were made and placed. The graphic on the window uses a scanned picture of a tree. The graphic was modified to include a window frame. The resulting graphic textured on the cubes placed in the walls became the windows. The cubes were placed protruding from the walls at the appropriate place and height. Several different shapes of windows were created to account for the different windows present in the building. The windows can only be seen from the inside of each specific floor.

Once the basic structure of the building had been established, it was necessary to furnish the offices. The furniture, such as computers, desks, and chairs, was created from measurements taken off actual furniture. Sketches were then drawn showing each piece of furniture from all sides. These sketches were used to establish corners to be used as vertices. Once vertices were established, faces or planes were identified and inputted into the file specific for each piece of furniture. The final touches that went into creating the furniture included selecting a color for each face and choosing appropriate images to be used as texture maps. When simple colors could be used to make the furniture look more realistic, final touches were left to that. In some cases however, it was necessary to create graphics to place on objects. One such instance of this is a graphic of the keys on a keyboard being placed on a simple shape to add a realistic touch to the keyboard. Each piece of furniture was created in a separate file to allow repeated use throughout both floors. Once files were completed, they were transformed into the floors. Some pieces, like a table and computer, were placed in groups. Other pieces were used in many different combinations. Several areas on each floor were furnished to give the effect of a complete office building. Many offices remain empty. Furnishing every office would have slowed down navigation and made the world appear choppy. This is

due to the amount of information that can be refreshed each time. Keeping files small allows the browser to refresh everything more often, providing smoother navigation.

The next step taken was to construct a simple model of the entire building to be the starting world. The building model is meant to be viewed from the outside, with simple links in each doorway to enter either floor. The model has dimensions equivalent to those of each floor, along with having correct placement of windows and doors. The idea of linking to each floor is present not only in the full building model, but it is also present in the stairways of each floor. Since navigating up and down a staircase would indeed be a difficult task, cameras were placed in each stairwell and outside door. A menu of links was placed in each of the named places and the links were hooked to the cameras in the connecting area. This way, navigation up and down stairs is not necessary. One can simply change to a different floor file.

Once links between floors were established, links had to be set up for gathering information on rooms and objects. Links to HTML information pages on specific objects were set up to be obtained through the object containing the link. It was then set up that information on specific rooms and areas could be gathered through an icon floating in each room. The icon created was a yellow question mark approximately 1 meter high. This icon was selected because of its universal meaning. This visible symbol was placed in a direct line of sight from each entrance to a room. The icon is in every room and closet. Each question mark has a description field identifying either the room number of the room or a description such as "stairs." The icons are linked to separate pages each containing the room number or description, a link back to the 3-D floor, and possibly links to people or programs.

The information that the question marks link to was gathered from pamphlets on division projects, the World Wide Web, and input from local personnel. A message was sent out to each member of the division requesting information on themselves and their job. Some information was received and then organized. The information received was included in a description of the person. Everyone in the division had a description, even if they did not respond to the message. Information on the projects was obtained through a booklet on division projects. Local HTML files had previously been created that gave information on all of these projects. These files were revised to meet the style and content of the project. All of the pages on people and projects were linked based on who was involved in which projects.

Information was also gathered on things in the office such as printers, restrooms, and conference rooms. Generic layout pages were created for many of these items to show the possibilities of the project. For example, the conference room information page contains a listing for times the room is reserved. This listing was filled with random times, not actual reserved times. Other information pages, like the printer pages, contain actual information on the area being discussed. Links were established between information directories and these information pages. Along with the information pages on objects and areas, a directory listing all building 190 personnel, their phone and intercom numbers, and their room number was created. The phone directory is divided into divisions, and the HRGO personnel are linked to their personal description. Pages that go several layers deep were installed with "back" or "top" navigation buttons.

It was decided that these information and personal pages needed to be organized into a user friendly layout. The chosen layout was a framed page with a navigation banner on the top, a frame on the left side to display menus, and a main area to view information and three-dimensional worlds (*see Figure 1*). This layout allows the user to always return to the home page, or to switch to any main page, from any point in the program. All information pages, VRML worlds, and personnel pages were linked to the main page. Main topics were listed as hyperlinks in the navigation banner. Several simple home pages were created as starting off points for the program. They contain the links displayed in the banner and explanations of each topic. From the home or starting page, any of the other information pages or VRML worlds can be accessed.

Once the pages and worlds were completed and all the links were established, the program was tested. The links were all tested and the information presented was double-checked. Comments and suggestions from advisory personnel were entertained and modifications were made. The program was finalized at its current stage. Notes were made on possible expansions and improvements, along with method notes of what was completed, to aid in the on-going revisions necessary on a project of this type.

Discussion of Problems

During any project, one encounters problems and makes certain design decisions. In accordance with this fact, this project caused numerous obstacles. Unfortunately, solutions were not discovered for all of the known problems. Decisions had to be made to account for the unsolved problems and to fix the solved ones.

In today's high-speed, technological world quickness contributes greatly to an employer's decisions on which programs to use. No user would want a slow, tedious program to find information. In production of this project, speed definitely became a factor. In order to view three-dimensional worlds with realistic response times, one must use a Pentium computer. Even on a 486 computer with slightly less speed, a considerable difference in response time was noticed. In addition, the current Netscape version does not cache VRML worlds as it does HTML pages. Every time a user would want to revisit a previously loaded world, the entire world would have to be reloaded. No solution could be found to solve this caching dilemma in Netscape. Maintaining a basic structure with limited detail reduced the response time of the program. Upon completion of the building, animation was contemplated, however, this slows down the whole program. It was necessary to turn off the animation in order to move through the current VRML world, to another world, or to an HTML page.

In order to accommodate the computer memory size and software memory restrictions, one must limit the size of program files. At the beginning of this project, modelers were thought to add to the ease of production. However, these modelers eventually became cumbersome and produced large files. In the same way, textures added to the program created enormous files, also affecting the speed of the program. To accommodate for this problem with the textures, changing the image formats was a necessity. Therefore, the necessity of split files became apparent to solve this dilemma.

The large size of some of the files not only caused problems for the computer, but also for the authors of these files. This problem dictated the necessity of comments. Without multiple comments in each program segment, the finding of errors would be extremely difficult. Comments also eased the connection of the various files. It is to be hoped that the included comments will assist those who endeavor to edit the program segments in the future.

The visual aspects of VRML also produced problems in development of the three dimensional floors and building. When using cubes, one could see the seams where two cubes came together. No solution could be found to solve this problem, even after considerable time was spent in the effort to fix it. Another problem occurred when two faces from different figures were placed next to each other. The faces on one of the figures tended to show through the other side of the other figure. For example, in the three dimensional second floor, one can see a bookshelf showing through an office cubicle wall when "walking" down the hall. Once again, after trial, no solution was found. Even moving the objects away from the walls did not produce the intended results. Lastly, the visual effect called texture mapping also caused problems. One must piece a texture onto a flat cube or an indexed face before placement in the picture because textures cannot be placed on only certain portions of cubed walls. All of the textures that were placed in the worlds became distorted. Due to this deformity and a lack of good pictures to use as textures, the creation of textures became necessary. Because of the project developers' part in developing the textures, the pictures were easily edited to counter the distortion produced by the VRML viewer.

Results

As a result of this project, a basic office intranet was established. This intranet includes VRML models of the building and its floors, HTML information pages, and sample multimedia clips. The VRML worlds contain links to the HTML pages as well as HTML to VRML links. Some of the pages contain information on printers, conference rooms, building personnel, and division projects. The worlds and information currently available are meant to be revised and updated as changes occur. The pages and worlds that have been produced are meant to be a starting point for a finished office intranet.

As well as an office intranet, the project provided insight into using Web technologies in logistics efforts. One example is the development and presentation of electronic technical manuals for Air Force maintenance. Through HTML pages, maintenance technicians will be able to navigate electronic manuals more efficiently and effectively than the current paper manuals. Closely related to maintenance is Aircraft Battle Damage Assessment

and Repair (ABDAR). Using VRML to represent the aircraft's internal components, the assessment teams will be able to get an idea of what damage might exist without disassembling the aircraft. Another area of consideration is in the training field. The trainees can watch videos demonstrating their task, work with three-dimensional models with animation to practice, and read information on HTML pages. Lastly, VRML allows computerized representation of real world objects in a more realistic way. This more realistic representation will benefit the visualization of complex logistics processes by communicating a better understanding of these processes.

Further Developments

As in many cases, this project will never be truly done. Additions, revisions, up-dates, and advancements in techniques will always be necessary to keep it functioning at a productive level. Even before this series of work on the project was completed, room for expansion and improvement was noticed. Due partly to time, knowledge, and available technology, all possible aspects of the project were not included. Among the aspects not included are animation, scripting, forms, and multimedia.

Animation was not included in VRML worlds of this project because of current VRML specifications. The animation that is currently available slows down navigation in a world to an extent that makes the animation ineffective. This reduced response time is attributed to the fact that the computer must constantly return to the source to obtain the next series of animation. The ability to animate using programming languages was not a possibility because of the lack of experience of the project developers. While animation can be achieved in several ways, none of them currently met the needs of the project. With VRML 2.0, animation will be an established part of the language, hopefully allowing animation to be incorporated effectively into VRML worlds. Animation on HTML pages also slows usage, but is better established and can be incorporated more smoothly. As animation becomes more robust, it may be incorporated into this project and other efforts.

Imagemaps and text fields are two of the elements commonly seen on effective Web pages. Incorporating both imagemaps and forms into HTML documents requires a server, which was not available for this project. The ability to use CGI scripts would have allowed the inclusion of data pages that could be updated. An example use of

this element of HTML is a sign-in/sign-out board. Personnel in the division would be able to keep track of when coworkers are out of their offices. Another possible use of CGI scripting would be a reservation form for conference rooms, equipment, etc. Information could be kept current by using a "Submit Changes" form that would help maintain accurate HTML pages.

Multimedia is another element seen on popular web sites. Multimedia includes video clips, sound bites, and animation, among other things. Multimedia brings a vitality to the internet that was seen only before from CD-ROM applications. Multimedia links were included to demonstrate their possible usage in this project. Incorporation of multimedia data can further enhance the information visualization possibilities demonstrated through HTML and VRML.

This project was first undertaken from a building structure and utilities maintenance angle. When it was decided that many of the components that should be included in such an undertaking could be better presented through means other than VRML, the building and division information presentation position was adopted. Though the structural aspect of the building was somewhat ignored in VRML, room exists for including information on such things as computer networks, maintenance, electrical, sprinklers, and heating on HTML pages. Presenting this information along side a proportionate building model allows data to be displayed in a more effective format while maintaining a 3-D presentation. Along with presenting structural maintenance information, equipment information such as serial numbers and quantities could be included. If furniture and computer equipment were to be placed in each room, links could be created revealing ADPE identification numbers, serial numbers, and make and model information. All of this information could be included with the present information or used to establish a separate facility management information system.

Conclusion

This project was successful in fulfilling the objective. A start for an intranet and WWW home page was established. VRML files were created and linked to HTML pages. Information was gathered and presented in a

format not conventional to standard presentations. This use of a different approach brought a benefit to AL/HRG. Possible capabilities of HTML and VRML were investigated and shown to AL/HRG personnel. These uses may now be applied to existing and future logistic research efforts.

This project also helped to establish that at this time VRML is about presentation and appearance, not exactness or detail. This project was additionally successful in this aspect. The VRML files were kept small while maintaining a quality appearance. This same attribute was extended into the HTML pages. Along with being well displayed, all aspects of this project have been left open ended. This allows expansions and improvements to be made easily. The possibility exists to build onto what has already been accomplished. Creating a project in this way allows it to produce benefits in its current stage, as well as changes are made in technology.

The application of HTML and VRML did enhance the information displayed in this project. Without VRML and HTML it would not have been possible to effectively display a three-dimensional model of building 190 along side hypertext documents. This ability given to anyone through the World Wide Web should be put to use by AL/HRG in their logistics research programs. WWW technologies will benefit projects because of the user-friendly interface and realistic information display. The increasing enhancements being made to HTML and VRML will give them even more power as effective tools for multimedia presentations, models, displays, manuals, and training.

File Edit View Go Bookmarks Options Directory Window Help

file:///al/vrml/framehom.htm

Building 190 - WPAFB, OHIO

Through this page you can...

View a 3D image of the building.

View 3D images of both floors.

See a directory of building 190 workers.

Read about the people working in the building.

Look at explanations of the various HRGO projects.

Access other information on the building and WPAFB.
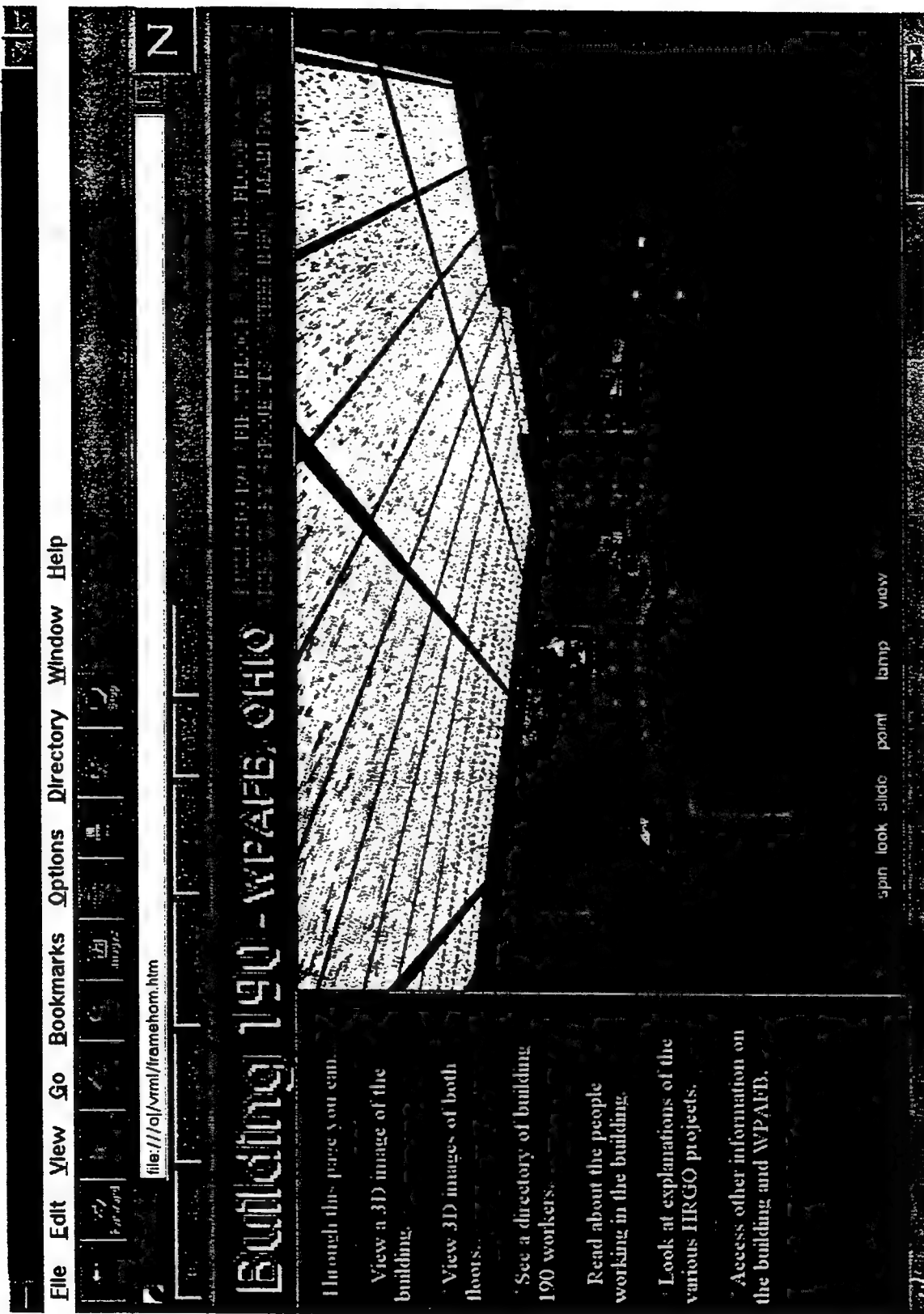
spin look slide point lamp view

Figure 1 - Screen capture showing frames and VRML

References

Matsuba, Stephen, and Bernie Roehl. <u>Special Edition Using VRML</u>. Indianapolis: Que Corporation, 1996.

Nadeau, David R., Andrea L. Ames, and John L. Moreland. "Optimizing the Performance of VRML Worlds." <u>Dr. Dobb's Journal</u> July 1996 : 16-24.

<u>Netscape</u>. Vers. 3.0b5aGold. Computer software. Netscape Communications Corporation, 1996.

Savola, Tom. <u>Special Edition Using HTML</u>. Indianapolis: Que Corporation, 1995.

<u>The Virtual Reality Modeling Language Specification</u>. World Wide Web Page, July 30 1996. Vers. 2.0, Final Working Draft, ISO/IEC WD 14772.

ELECTROCHEMILUMINESCENCE (ECL) SENSORS
RESEARCH AND DEVELOPMENT

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Final Report for:
High School Apprenticeship Program
Armstrong Laboratory

Sponsored by:
Air Force Office of Scientific Research
Bolling Air Force Base, DC

and

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August 1996

ELECTROCHEMILUMINESCENCE (ECL) SENSORS
RESEARCH AND DEVELOPMENT

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Abstract

Two projects involving Electrochemiluminescence were studied. First, ECL was used to determine the binding affinity between copper(II) and 3,4-diaminotoluene (DAT), 1,2-diaminoanthraquinone (DAQ), and 9,10-diaminophenanthrene (DAP). Results indicate that 1,2-DAQ and 9,10-DAP exhibit higher ECL intensity, but copper(II) has little effect on these ligands. Second, experiments were performed to characterize the natural ECL material in a tunicate (*Molgula occidentalis*). Tunicate blood pigments were studied on a fluorescence microscope and in polyacrylamide gels on a UV transilluminator. The blood cell lysate fluoresced in both cases. The cell lysate was further studied through size exclusion chromatography and tested for ECL intensity and absorbance at 325nm. The techniques suggested the natural ECL molecules to be of moderate molecular weight. ECL has numerous applications. These two studies helped to answer questions about this emerging sensor technology.

ELECTROCHEMILUMINESCENCE (ECL) SENSORS
RESEARCH AND DEVELOPMENT

Alison B. Martin

Introduction

Electrochemiluminescence, or ECL, is electrically induced light production. It acts as a "lights on" sensor for detecting the specific binding of any two molecules. It is similar to fluorescence, or glow-in-the-dark, except that fluorescence is light induced light production. ECL uses electrons and fluorescence uses photons. ECL is a promising sensor technology because of its molecular recognition, high sensitivity, low power consumption, and potential for miniaturization.

The instrument used to determine ECL intensity is the Origen Analyzer by Igen Corporation (Gaithersburg, MD). It has a carousel that vortexes the samples to be run, a box that houses the electrochemical flow cell and the photomultiplier tube, and a computer that outputs the data. The ECL reaction between ruthenium trisbipyridine (Ru(bpy)3^2) and tripropylamine (TPA) is a popular model system. Ru(bpy)3^2 and TPA are both oxidized on the surface of an anode. They are then excited to form a high energy state. When the molecules revert to their lower energy state, they release photons at a wavelength of 620nm. The Origen Analyzer quantitates the amount of light emitted. (Fig. 1)

ORIGEN Technology Reaction
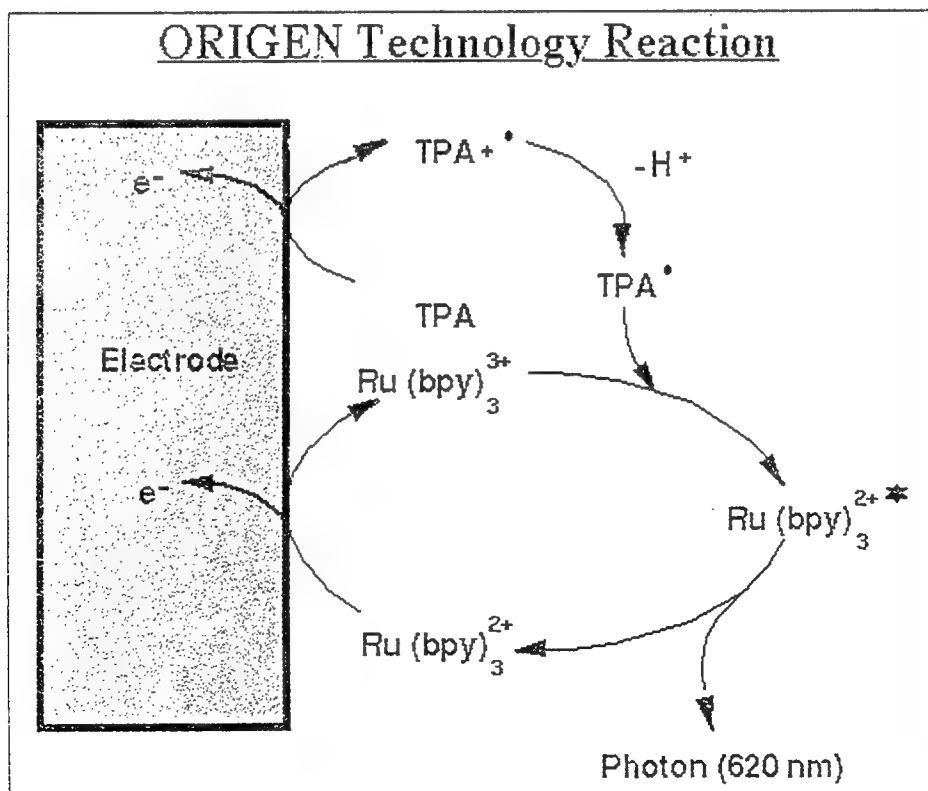
Background

There are several types of ECL molecules. One of these is metal coordination complexes. The concept of binding ligands and other molecules to positive ionic metals has led to a great number of questions. It seems feasible that ECL can detect TNT breakdown products and metals, and that there are mnay natural ECL ligands to metals. These two problems have led to research involving diaminotoluene (DAT; TNT breakdown products) molecules and marine animals known as tunicates, which concentrate some metal ions.

A. Previous work has been done by Dr. John Bruno to test the ECL of 3,4-diaminotoluene and 2,4-diaminotoluene to several metal ions. Using ECL, it has been shown that the copper(II) cation binds well with 3,4-DAT, and the gold (I) cation binds well with 2,4-DAT. The ionic radius of copper(II), 0.87Å, is smaller than the ionic radius of gold (I), 1.51Å. An ECL size dependence was theorized because this would allow for the ions to fit nicely between the spacing of the amino groups. Copper and gold are both group 1B transition metals so an electron configuration dependence was also theorized. Other experiments involving the copper(II) and 3,4-DAT reaction have been done. One study, recently accepted for publication (1), shows that ECL intensity increases with the concentration of 3,4-DAT. It also shows a slight time dependence on ECL intensity. (Fig. 2)

Cu(II)-3,4-Diaminotoluene ECL
(Fixed Cu(II); 32 ppm)
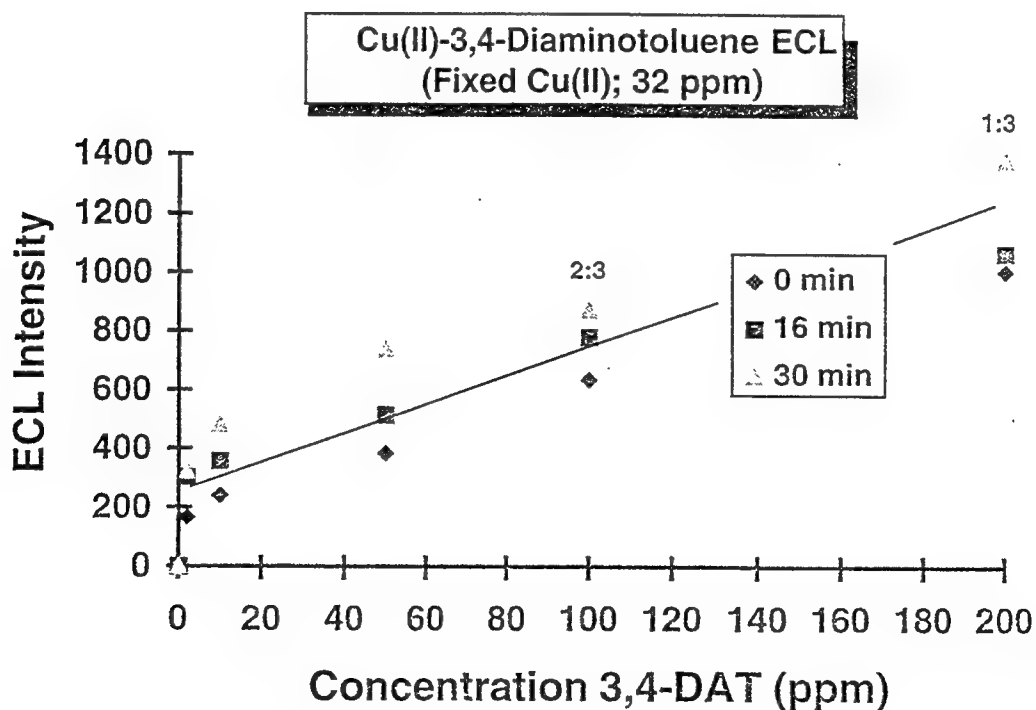
B. Tunicates are marine invertebrate animals that are often called "sea squirts." They have two siphons, branchial and atrial, through which they take in and expel water. They are filter feeders because they have a small mucous membrane where they filter phytoplankton for food. These small animals tend to chelate and concentrate metals up to 10^8 fold over ambient sea water concentrations. They are already known to have a high affinity for iron (Fe) and vanadium (V). Their high affinity for metals leads to investigations about their ECL properties. Because of this fascinating phenomenon, tunicates have been accredited with cleaning up several bodies of water, including Tampa Bay. (Fig. 3)
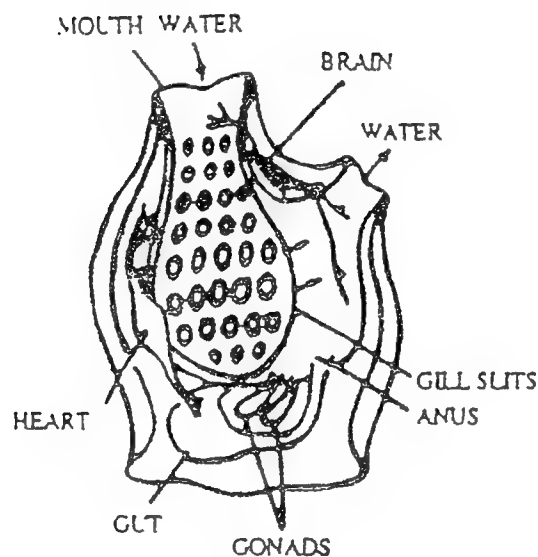
<u>Problem</u>

A. ECL Kinetic rings study -- It was theorized that more highly conjugated ortho diamino aromatic compounds (vs. 3,4-DAT) would exhibit higher ECL with copper(II) ion. For this reason, 1,2-DAQ and 9,10-DAP were studied in addition to 3,4-DAT. (Fig. 4)
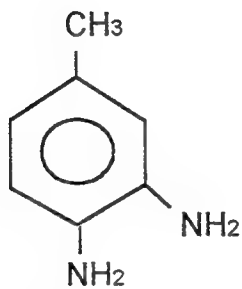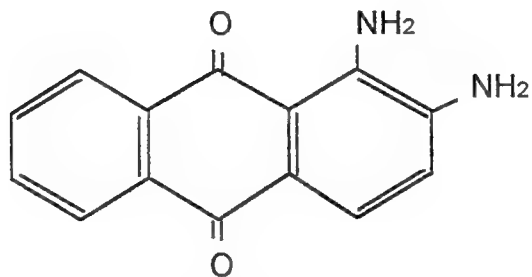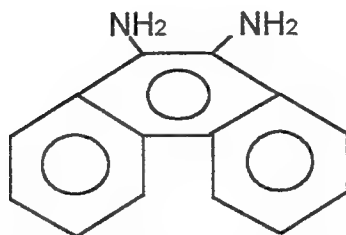

3,4-Diaminotoluene (3,4-DAT)

1,2-Diaminoanthraquinone (1,2-DAQ)

9,10-Diaminophenanthrene (9,10-DAP)

B. ECL Tunicate study -- There are many species of tunicates. One of the most readily available to study in the nearby St. Andrew Bay was *Molgula occidentalis*. Its blood, although not entirely pure, is easy to extract. The blood pigments from this tunicate are often called "tunichromes" and exhibit strong ECL with some metals (2). Little is known about the actual molecules that exhibit ECL in tunicates, so studies were done in an attempt to describe and characterize these substances.
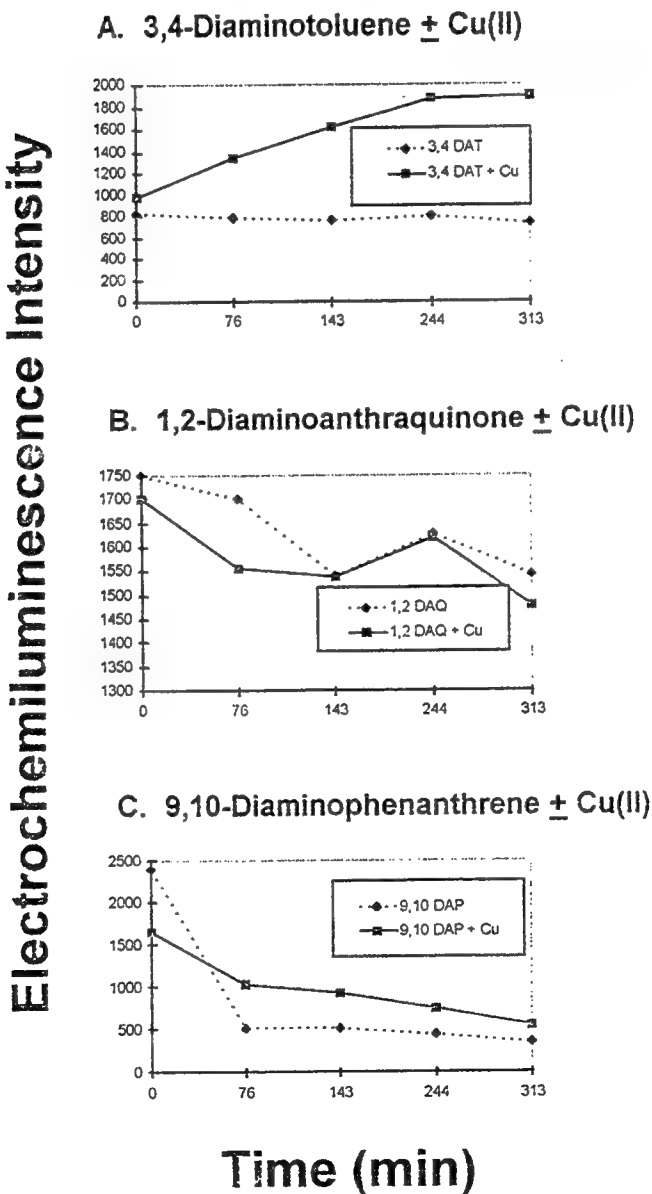
Methodology

A. Kinetic rings study -- The amounts of 3,4-DAT, 1,2-DAQ, and 9,10-DAP were fixed at 200μl and the amount of copper(II) was fixed at 32μl. Each diamino molecule was then combined in a small test tube with or without copper(II) and volume was brought to one ml. ECL was tested at five different time periods ranging from 0 to 313 minutes.

B. ECL Tunicate study -- In an attempt to characterize the ECL substance in *Molgula occidentalis* blood, several tests were run. **1.** Because ECL and fluorescence are so closely related, the blood was viewed under a fluorescence microscope at 420nm. **2.** Fresh blood was then separated into cells and serum using a centrifuge. The cells were lysed in Milli-Q water. Both the cell lysate and serum were loaded in a 4-20% gradient SDS-polyacrylamide gel. The gel was electrophoresed until the bands had migrated to the bottom of the gel. The gel was place on an ultraviolet (UV) transilluminator and studied for fluorescence at 312nm. **3.** In an attempt to determine the size of the ECL molecules, 1 ml of blood cell lysate was run through a Sepahdex G25 Size Exclusion Chromatography Column. The cell lysate was eluted off the column using 12 fractions of 600μl each of 460mM sodium chloride (NaCl) buffer solution. Each fraction was then tested for ECL intensity and absorbance at 325nm.

Results

A. Kinetic rings study -- In studying more highly conjugated ortho diamino aromatic compounds, ECL intensity did increase. The ECL intensity for 1,2-DAQ was more than double that of 3,4-DAT and the ECL intensity for 9,10-DAP was triple that of 3,4-DAT. However, when copper(II) was added to the more conjugated ligands, there was little or no effect on the ECL intensity of 1,2-DAQ and 9,10-DAP. When copper(II) was added to the 3,4-DAT, ECL was greatly enhanced and came to equilibrium over time. (Fig. 5)

ECL Kinetic Studies

A. 3,4-Diaminotoluene ± Cu(II)

B. 1,2-Diaminoanthraquinone ± Cu(II)

C. 9,10-Diaminophenanthrene ± Cu(II)

Electrochemiluminescence Intensity

Time (min)

B. ECL Tunicate study -- 1. When looked at under the fluorescence microscope, the *Molgula occidentalis* blood cell lysate fluoresced a lime green color with a small bit of red. This is very rare in the animal kingdom. **2.** When the PAGE (Polyacrylamide Gel Electrophoresis) was viewed on the UV lightbox, the blood cell lysate, in lanes 2 and 3, fluoresced. The fluorescent bands were very close to the bottom of the gel (<7.6 kD), near the dye front. The serum did not fluoresce. (Fig. 6)

Molgula occidentalis blood in 4-20% gradient polyacrylamide gel
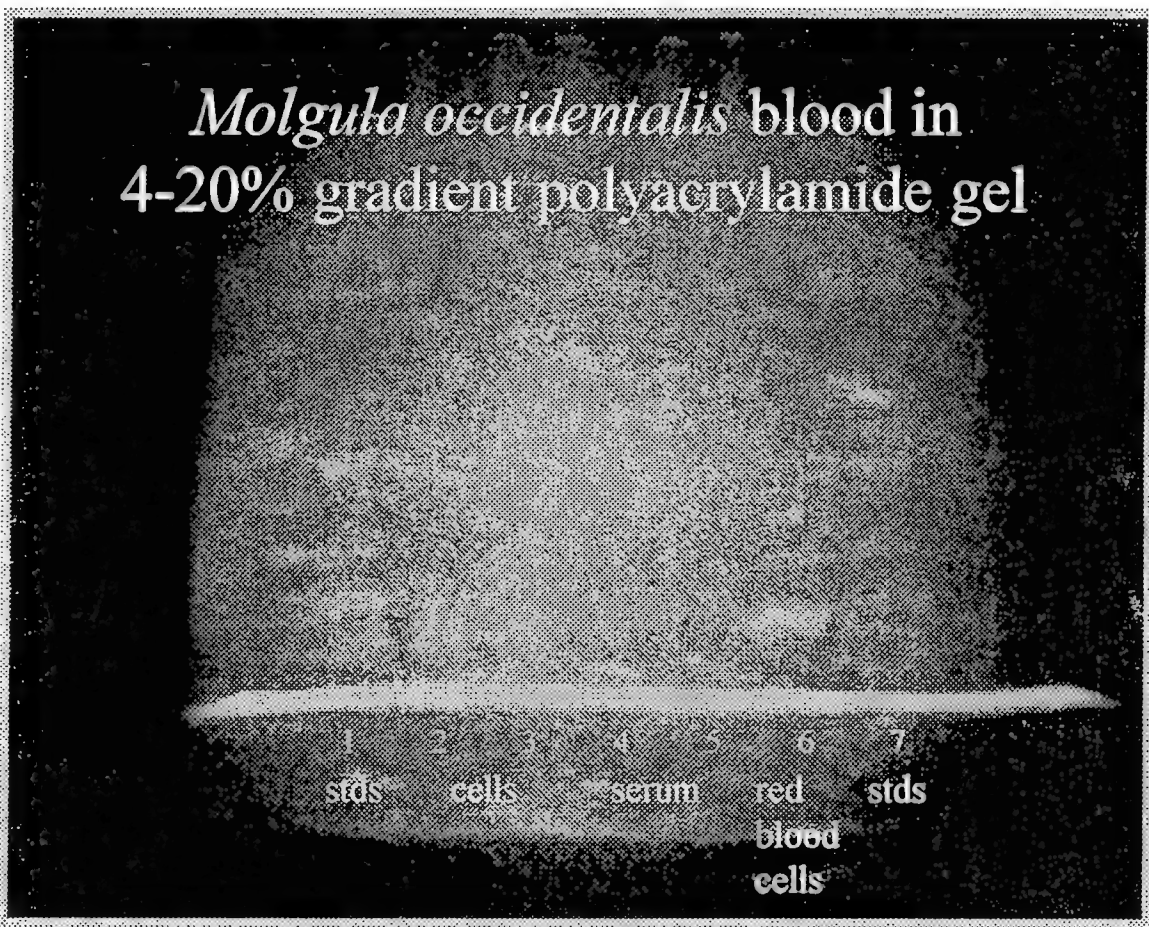
3. When tested for ECL intensity and absorbance at 325nm, fractions 2-6 exhibited the greatest increases. Both the ECL and absorbance peaked around fractions 4 and 5. There were also small peaks in ECL at fractions 9 and 11 and a small peak of Absorbance at fraction 9. (Fig. 7)

M. occidentalis Blood Cell Lysate
(Sepahdex G25 Size Exclusion Chromatography)

A. Electrochemiluminescence

B. Absorbance
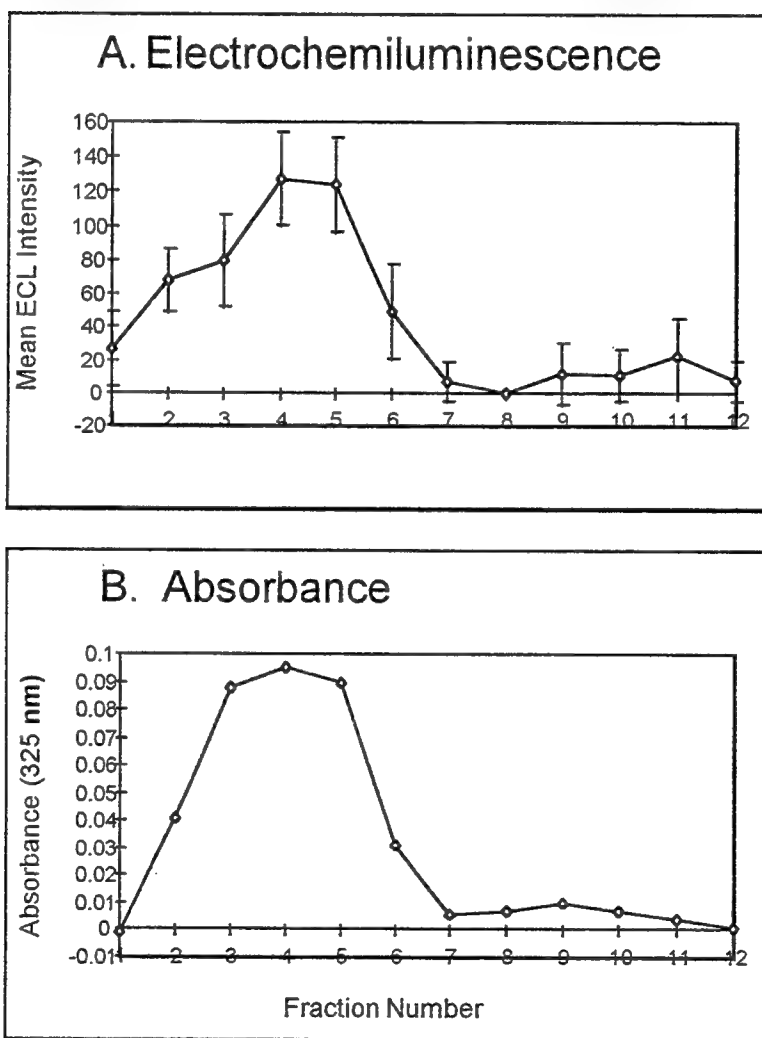
High MW   Low MW

Conclusions

A. Kinetic rings study -- ECL intensity does increase with more highly conjugated ortho diamino aromatic compounds. The binding of copper(II) to these molecules, however, inhibits or has no effect on ECL intensity. 3,4-DAT is the most robust molecule for copper(II) detection compared to other molecules studied.

B. ECL Tunicate study -- **1.** The two different colors of fluorescence, green and red, of the *Molgula occidentalis* blood could mean that there are two ECL substances. The fact that the fluorescence came from the blood cell lysate indicates that the ECL molecule is inside the cells and is released when the cells are lysed. **2.** That a band from cell lysate fluoresced in the gel, while the serum did not, also suggests that the ECL molecule is inside the cells. Because the fluorescent bands migrated so low in the gel, this shows that the ECL molecule is of moderate to low molecular weight. Compared to the standards in lanes 1 and 7, the molecules are less than 7.6 kD. This could imply that the molecules are attached to proteins because this is the region where proteins migrate. **3.** In the Size Exclusion Chromatography Column experiment, the curves of the graphs are so similar that they show a direct correlation between ECL and absorbance. The work also indicates that the majority of the blood cell lysate was eluted off the column in fractions 2 through 6, peaking at 4 and 5. This further demonstrates that the ECL molecules are of moderate molecular weight and could be attached to proteins. The smaller peaks at fractions 9 and 11 are indicative of a second, smaller ECL molecule, which may be fragmented off the protein seen in fractions 2 through 6.

References

1. Bruno J.G. and Cornette J.C., An electrochemiluminescence assay based on the interaction of diaminotoluene isomers with gold(I) and copper(II) ions. *Microchemical J.*, in press, 1996.

2. Bruno J.G., Collard S.B., Kuch D.J., Cornette J.C., Electrochemiluminescence from tunicate, tunichrome-metal complexes and other biological samples. *J. Biolumin. Chemilumin.*, 11:xx-xx in press, 1996.

THE BIODEGRADATION
OF AMMONIUM PERCHLORATE
IN A FIXED BED REACTOR

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Final Report for:
High School Apprentice Program
Armstrong Laboratory

Sponsored by:
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Bolling Air Force Base, DC

and

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August 1995

20-1

THE BIODEGRADATION
OF AMMONIUM PERCHLORATE
IN A FIXED BED REACTOR

Lisa A. Mattingley
Mosley High School

Abstract

The biodegradation of AP in a fixed bed reactor was examined. Ammonium perchlorate constitutes 14-70% of the components in solid rocket propellant. The widespread use of ammonium perchlorate in the manufacturing, refurbishment, and disposal have led to groundwater contamination. A fixed bed reactor allows large volumes of contaminated groundwater to be treated with removal of Ammonium perchlorate. The fixed bed reactor works by pumping in pH controlled media and an AP waste stream into an up-flow system. The anaerobic bacteria which are attached to diatomaceous earth pellets, reduce the perchlorate levels. Perchlorate concentrations were approximately 500 ppm in the simulated waste stream, 200-300 ppm exiting the reactor column and 0-20 ppm in the effluent of the holding tank. These results demonstrate that a biofilm has formed and it is reducing perchlorate.

THE BIODEGRADATION
OF AMMONIUM PERCHLORATE
IN A FIXED BED REACTOR

Lisa A. Mattingley

Ammonium perchlorate (AP) has been allowed to contaminate groundwater and soil in

past years. A bacteria, *Wolinella succinogenes*, or HAP-1, has been found to reduce perchlorate.

Various reactors have been tested, but for this specific problem the fixed bed reactor is the best

solution because of its ability to treat large quantities of contaminated wastewater. It is a system

comprised of an influent stream (media and AP), the column (housing HAP-1 bacteria), and

effluent. The bacteria has attached and created a biofilm that is successfully decreasing

perchlorate levels.

Defense industries use ammonium perchlorate in their solid rocket propellants as an

oxidizer. As the motor casing is cleaned with high pressure water, a contaminated waste stream

is created. For many years this waste was ignored and in effect seeped into the ground and soil.

Diagram A depicts the wastewater filtering through the soil and eventually polluting an aquifer.

Areas of groundwater contain 6,000 parts per million (ppm) of ammonium perchlorate have been

created. Water movement transports AP throughout the aquifer. Contamination of the public

water system creates a public health hazard. The fixed bed reactor would be useful for treating

this groundwater with AP concentrations of 6,000 ppm. By destroying the source, the smaller concentrations should be reduced through natural attenuation.
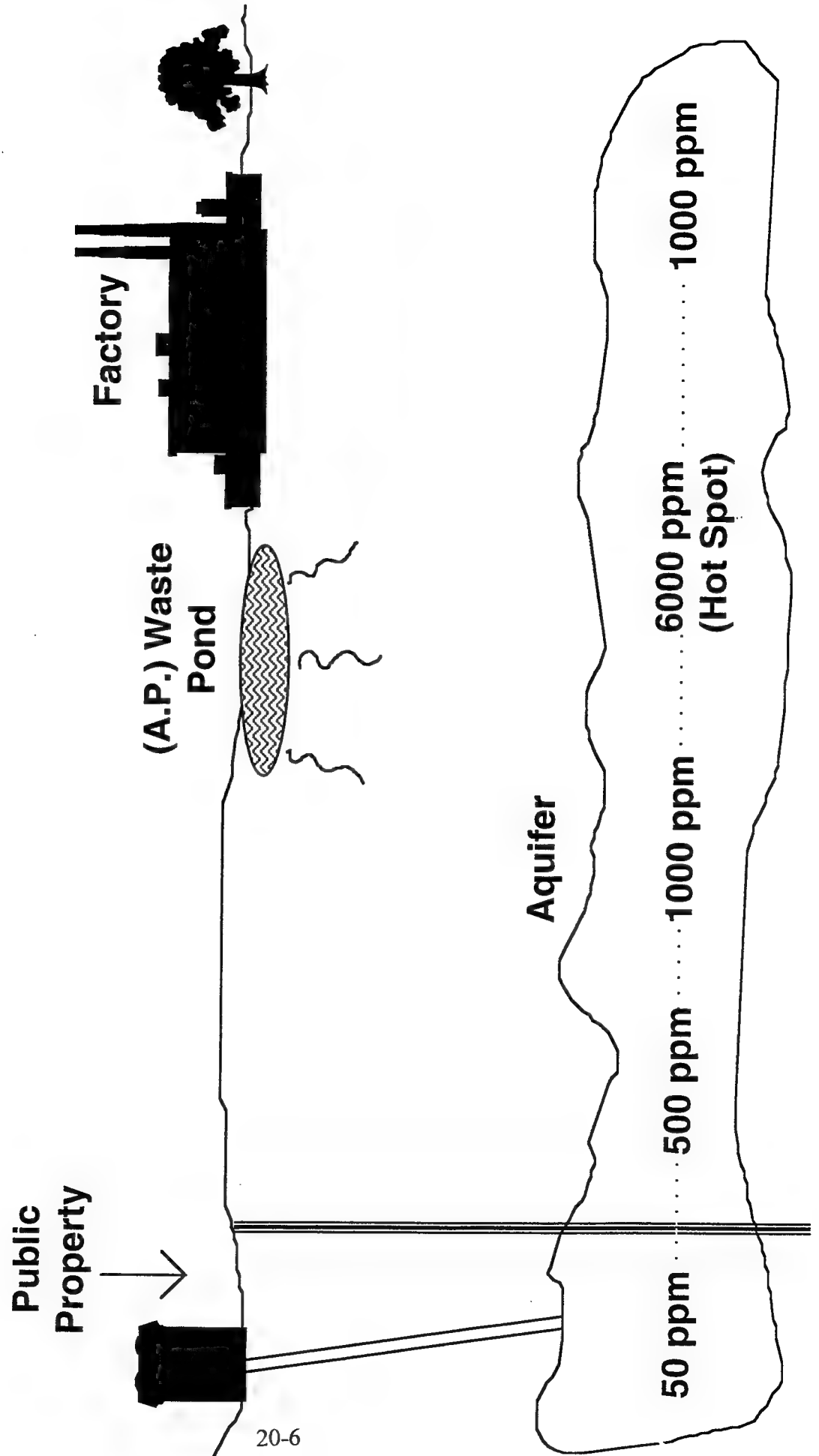
Diagram B shows the fixed bed reactor system. A Brewers Yeast Extract (BYF) solution provides nutrients and with a flow rate of 1.25 mL/ min. The pH 4 to prevent microbal growth. A 500 ppm concentration of ammonium perchlorate is pumped in at 50 mL/ min.. The system is sparged with nitrogen to keep it anaerobic. The BYF and AP are mixed and the pH level is adjusted to 7.0 the bacteria in the column are not killed. This is where the first sample is drawn to be tested. The perchlorate level should be near 500 ppm. Next, the AP. enters the column. The column is filled with diatomaceous earth pellets and anaerobic bacteria. The pellet size is 6 mm diameter and 13 mm long with a mean pore diameter of 20 μm and a surface area of 0.27 sq. m/gram. These pellets provide surfaces on the surface and inside the pore spaces of the pellet. As the up-flow system moves the liquid up, perchlorate is reduced to about 200 ppm. Next the effluent is held in a tank where the perchlorate levels drop from approximately 200 to 0, before it is pumped into the waste stream.

Diagram C depicts the enumeration of bacteria per gram of diatomaceous earth. There are fluctuations in the numbers between days 14 and 21. Probably due to fluctuations in media, pH, residence times, or nitrogen. However, the results demonstrate a bacterial biofilm was established on the pellets. Diagram D shows the actual amount of perchlorate reduced. Three phases are evident where the AP. concentration, flow rates, and media were altered. My work is primarily in the third stage. The top line is how much AP we pumped in which is 500 ppm. The second line is the reactor effluent and the third is after it has set in the holding tank. Our biofilm

Several conclusions can be made from the data. The fact that a biofilm has been established and it is capable of perchlorate reduction is significant because the bacteria is a multi-membered consortia. Also our rates of reduction are the highest to date. In the Continuous Stir Tank Reactor (CSTR) the highest rates were 0.7 g/hour. The fixed bed reactor has had rates of 0.9 g/hour. Also, this system may be applicable in the future to the reduction of nitrate contamination in groundwater waste.

Introduction to Problem

Factory

(A.P.) Waste Pond

Public Property

20-6

Aquifer

50 ppm

500 ppm

1000 ppm

6000 ppm
(Hot Spot)

1000 ppm

Diagram B

Methodology:

Fixed Bed Reactor (R4)

20-7

Diagram C

20-8

Perchlorate Reduction in Fixed Bed Rector from June 1996 to Prese
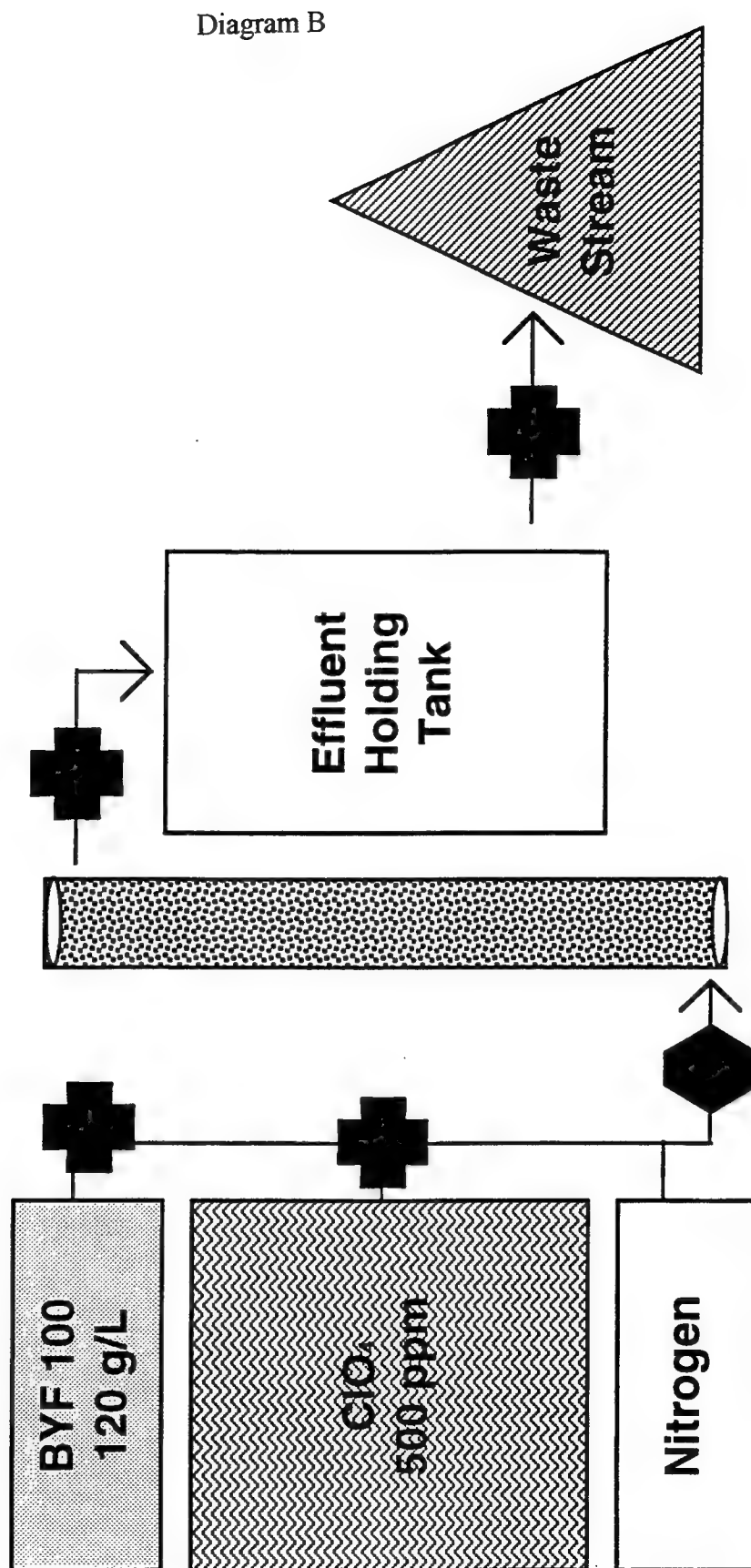
Priscilla M. Medina's report was not available at the time of publication.

THE STUDY OF GAMMA RADIATION PRESENT IN THE ENVIRONMENT

Lila Medrano

Louis W. Fox Academic and Technical High School
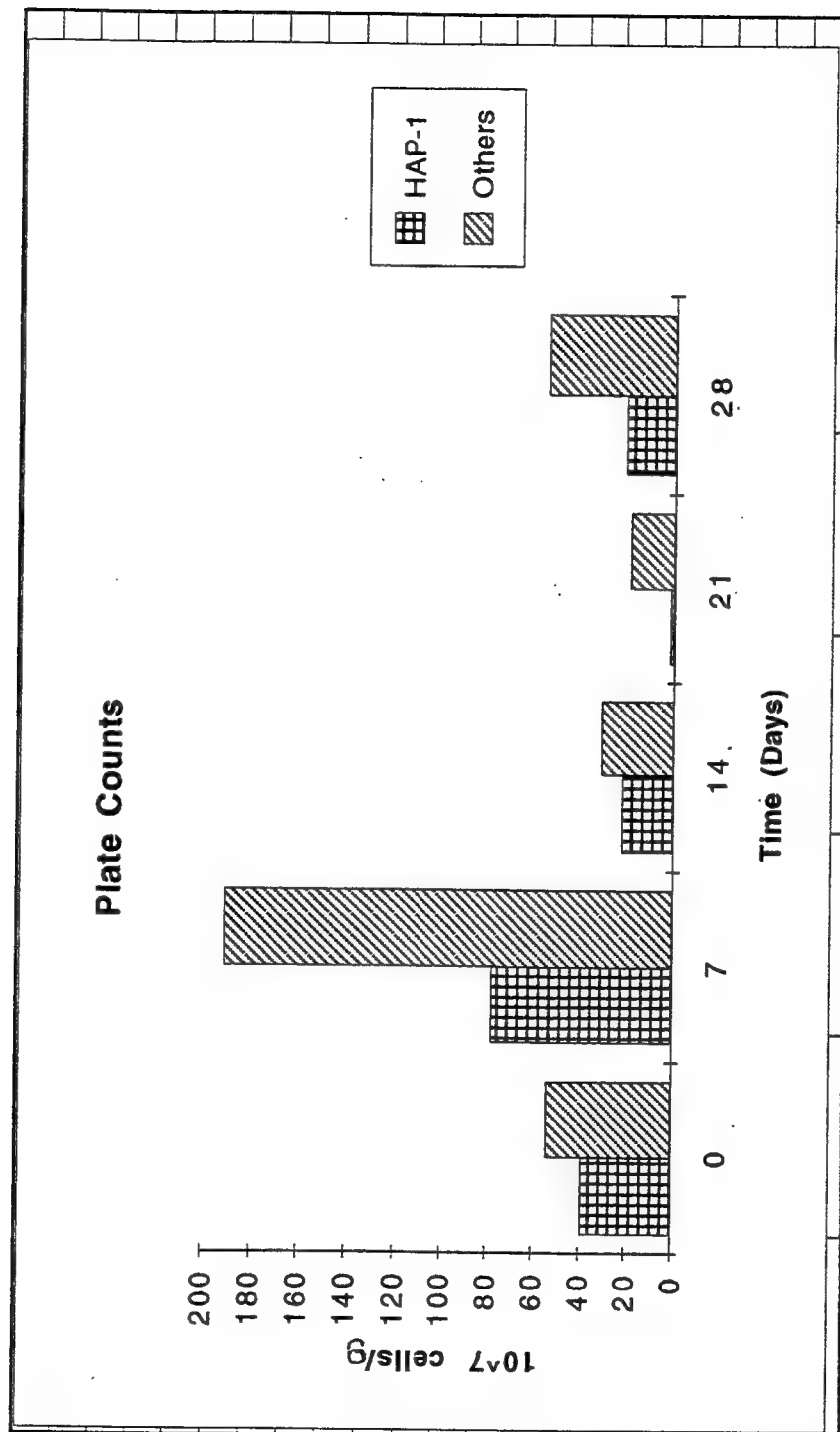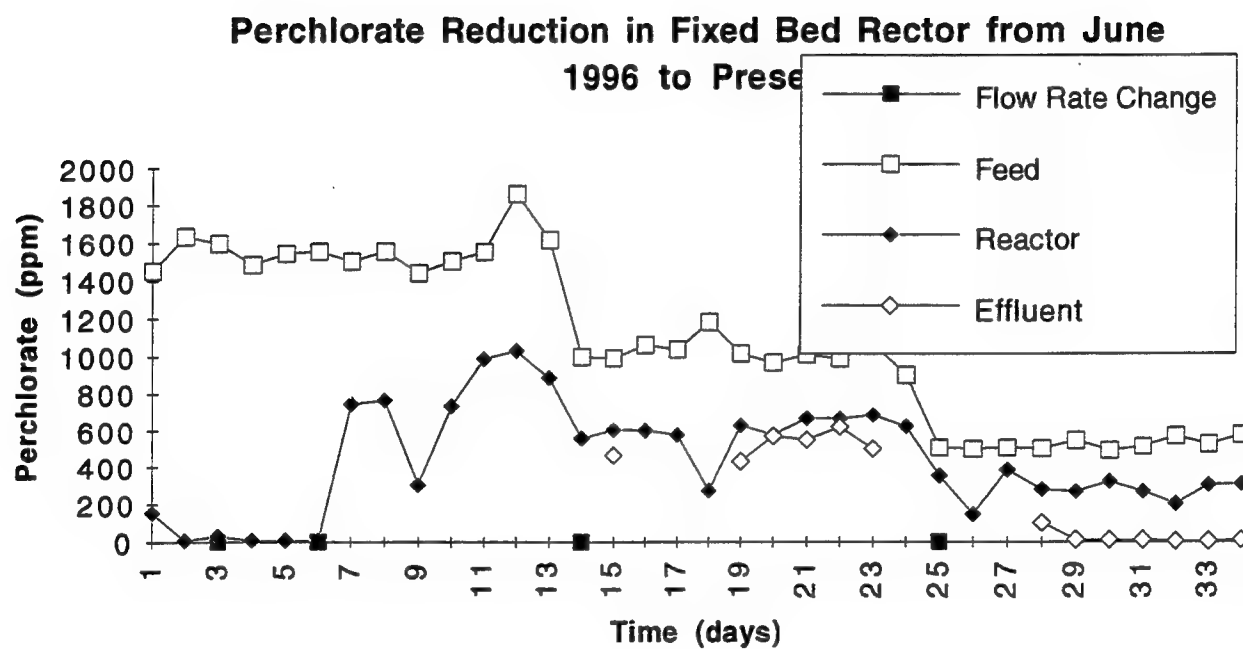637 N. Main Ave.
San Antonio, TX. 78205

Final Report for:
High School Apprentice Program
Armstrong Laboratory

July 1996

A STUDY OF GAMMA RADIATION PRESENT IN THE ENVIRONMENT

Lila Medrano
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Abstract

The concentration of this study was to determine the concentration of radionuclide activities present within my local environment. The instrument used to carry out this study was the Gamma Spectroscopy System. Samples of soil and water were brought into the lab and counted on the system. The counts were 10,000 seconds for each geometry (size and shape of the sample). The nuclide activities are detected by the interaction of the photon emissions (gamma rays and X-rays) with the hyperpure germanium detector.

The three radionuclides of interest were radium - 226, thorium - 232, and uranium - 238. Thorium - 232 and uranium - 238 were able to be detected by the presence of their daughter products: Ac -228 and Th - 234 , respectively. Radium - 226 can still be detected as such. The end results showed that the concentrations for the radionuclides in the samples collected did in fact coincide with the range of values set for the state of Texas.

A STUDY OF GAMMA RADIATION PRESENT IN THE ENVIRONMENT

Lila Medrano

Introduction

Radiation is energy in transit as high speed particles and electromagnetic waves. The term radiation includes all electromagnetic wave types and high energy particle emitted in nuclear or atomic disruption. Radiation occurs in our environment as natural existing background radiation. It surrounds us everyday in the form of visible light, ultraviolet (UV), microwaves, radio and television waves. The background radiation we come in contact with is not at the high frequency end of the energy spectrum. Therefore it is not capable of removing tightly bound electrons from the orbit around an atom. This kind of radiation is referred to as non-ionizing radiation. Radiation that does carry enough energy to cause ionization of atoms can be referred to as ionizing radiation.

Ionizing radiation occurs in two forms -- rays and particles. Ionizing radiation such as X-rays and gamma (γ) radiation travels as a wave with sufficient penetrating power to pass through the human body. Protection against the gamma and X rays are barriers of concrete, lead and water. Alpha (α)and betas (β) are fast moving particles of radioactivity given off by radioactive isotopes. Radioactive isotopes are unstable atoms releasing energy as electromagnetic radiation and/or particles by a process of decay called radioactivity.

Alpha particles emit from naturally occurring elements such as uranium and radium. An alpha particle is simply the nucleus of a helium atom with the mass of 4 units: 2 neutrons and 2 protons. Thus its relatively large size causes it to lose energy very quickly. The first layers of skin, a sheet of paper, or a few centimeters of air are adequate barriers from the effects of alpha particles. However, the body's cells react to radiation in such a manner when alpha particles are introduced to the body by breathing or swallowing effects can be seriously detrimental. These biologically damaging effects are due to alpha particles giving up their energy over a very short distance.

Beta particles are emitted from the inside of a nucleus and are identical to electrons. These particles travel at much higher velocities with an equivalent emission energy than alpha particles but are much lighter in weight. Due to the lighter weight beta particles have about 100 times as a much penetrating power. At a high energy, they can penetrate about 0.1 centimeter of lead, 1 centimeter of water and about 10 meters (30 feet) of air. Beta particles

also posses a unique characteristic and it goes by the term "brehmsstrahlung,", a German word meaning "braking radiation." In brehmsstrahlung the final slowing down of the beta particles causes the emission of X rays. X rays is energy transmitted in an electromagnetic wave due to changes in energy levels.

Along with alpha, beta and gamma particles and rays, neutrons are another type of particles. Neutrons are not the product of radioactive decay but come from collisions with atoms in the atmosphere and from the splitting, or the fission of certain atoms inside a nuclear reactor. Neutrons have no charge, are relatively massive and have a great penetrating power. The penetrating power of the neutrons accounts for the need for massive shielding around nuclear reactors. Water and concrete are the most commonly used shields against neutron radiation from the core of the nuclear reactor.

The degree of damage caused by ionizing radiation like alpha, beta, and gamma all depend on factors such as the dose received, the dose rate, type of radiation, the part of the body exposed, age and health of the person exposed. All cells within the body react differently to radiation. The types of cells more susceptible to radiation are those with a high rate of mitosis, undergo many cell divisions, are not specialized (embryonic and immature cells) and the red and white blood cells of the body. An acute exposure to ionizing radiation can have effect that can manifest with hours or days. Chronic exposure may cause effects that will manifest within years after the original exposure. No unique disease can be associated with long term exposure to radiation because of the time involved and the possible already existing conditions. Although the long term effects can't be defined, some possible effects are embryological defects, cataracts, life span shortening, cancer, and genetic mutations.

There are several ways to measure radiation . The quantity used to describe the energy content of a moving particle is the electron volt (eV). This is a small unit so more often the units of one thousand electron volts (keV), one million electron volts (MeV), or one billion electron volts (BeV or GeV) are used. The very high-energy neutrons emitted from a single fission event will have energy of about 2 MeV while thermal neutrons important in most nuclear reactors have energies only up to .5 eV (not KeV). Beta particles as emitted in radioactive decay range in energy from 50 KeV to about 13 MeV and gamma rays fall in the range from 10 KeV to 10 MeV. Other units of measurement are roentgen, rads, rem, and curies.

The roentgen is a unit used to measure a quantity called exposure. It can be used to describe amounts of gamma and x-rays in air only. It is a measure of the ionization of the molecules in a mass of air. The rad is a unit

used to measure a quantity called absorbed dose. This related to the amount of energy actually absorbed in some material and can be used for any type of radiation but it does not describe the biological effects of the different radiations. Rem (roentgen equivalent man) is a unit used to derive a quantity called equivalent dose. For the same amount of absorbed dose, all radiation will not have the same biological effects. Rem relates the absorbed dose in human tissue to the effective biological damage of the radiation.

The curie (Ci) and bequerel (Bq) are units used to measure radioactivity. The relationship between bequerels and curies is $3.7 * 10^{10}$ Bq in one curie. One curie is that quantity of a radioactive material that will have 37,000,000,000 transformations in one second. Often smaller units are used to express radioactivity like in one thousandth (mCi), one millionths (uCi) or even billionths (nCi) of a curie. One bequerel is the quantity of a radioactive material that will have 1 transformation in one second. It is often expressed in larger units like one thousand Bq (kBq), one million Bq (MBq) or even one billion Bq (GBq).

The concentration of this study was gamma radiation. Gamma radiation is electromagnetic waves or photons emitted from the center or nucleus of an atom. Gamma radiation cannot be deflected in magnetic fields like alpha and beta radiation. It has no charge and has a considerably larger penetrability the alpha and beta radiation. Although gamma radiation can be described as waves, they can also be considered as made up pulses of energy known as photons. These photons of energy act as if they were particles without mass but capable of interacting with the electrons of the material through which they pass. It is the interactive capabilities of these photons that causes ionization damage effects.

Discussion of Problem

At the present time there is a growing concern of radiation exposure, especially within the work place. The focus of my research was to determine the concentration of radionuclides present within my local geographical area. The purpose of this study was to familiarize myself with the amount of radioactivity there is within my natural environment and to do so by using the Gamma spectroscopy system.

The types of samples collected were soil and drinking and pond water samples taken from random locations within the area. The Gamma Spectroscopy System was used to run the analysis on the samples collected. The samples were collected, brought into the lab and prepared for counting. After the samples were prepared in the

appropriate geometry, the batches were analyzed at 10,000 seconds (approximately 2.7 hours) by the Gamma Spectroscopy System. The reports obtained from the Gamma Spectroscopy were used to determine the concentration in the samples of the following radionuclides: radium-226, thorium-232 and uranium-238.

Methodology

The methods used for the energy, FWHM, and efficiency calibration , background subtraction, quality control, and sample counting and analysis of the Gamma Spectroscopy System were performed in accordance to the Radioanalytical Branch operating instruction (BOI). This BOI is used by all personnel assigned to the Radioanalytical Branch.

The first process is the calibration. Calibration is the process of determining the characteristics of a detector system. Calibration establishes the channel / energy correspondence of the spectrum, as well as the detector efficiency and full width half maximum (FWHM). There are three basic sets of calibration parameters.

A.) **Energy calibration:** The energy calibration serves to correlate channel numbers with energy calibration factors which are off set, slope, and quadratic, used in the following equation :

$$energy = offset + slope * quad * channel^2$$

There are many factors that can affect the energy calibration including analog to digital converter (ADC) gain and offset, amplifier and preamplifier setup, the detector, and the detector high voltage. The energy calibration consists of making a pole-zero adjustment, setting the peaks to the appropriate channels, counting a spectrum and performing the energy calibration. The first step in performing an energy calibration is making a pole-zero adjustment. A source with Co-60 and Cs-137 energy lines only is placed on the G - 3000 sample changer. It is easier for the system to perform an automatic pole zero adjustment on two energy lines than on the eleven energy lines present in the calibration source. After the source has been counting for at least two minutes an automatic pole zero adjustment is initiated. The automatic setting is also check to assure it is working properly by being observed manually with an oscilloscope. The intensity, focus, position, and trigger level knobs are adjusted until the pulse can be viewed easily on the oscilloscope. After the automatic pole zero adjustment is complete, the pulse should return to the base line on the oscilloscope without any overshoot or under shoot. Once the pole-zero has been adjusted, the

two line source (Co-60, Cs-137) is replaced with the appropriate calibration source for that detector. After two to three minutes of counting, each of the eleven peaks are compare to the peak centroid channel in the chart provided.

Nuclide	Energy	Channel
AM-241	59.5	119
CD-109	8	176
CO-57	122	244
CE-139	166	332
HG-203	279	558
SN-113	391	782
CS-137	661	1323
Y-88	898	1796
CO-60	1173	2346
CO-60	1332	2665
Y-88	1836	3672

If they don't do not match (plus or minus 0.5 channels), they are adjusted using the amplifier gain and zero offset adjustment. The gain adjustment is a logarithmic adjustment that shifts peaks of higher energies over far more than at the lower end of the spectrum. The zero adjustment shifts all peaks equally (adjust the distance between peaks). Once these adjustments are made a new count begins to ensure that the peaks are falling into the appropriate channels. Once this has been accomplished the source is removed from the detector. After the peaks have been manually set at their appropriate channels, the automatic energy calibration must be performed. The preset live time is set to 2000 seconds and then the count takes place. The calibration is performed automatically.

B.) **FWHM:** The FWHM is a measure of the width of the peak at half of its maximum height. The FWHM calibration correlates energy with peak width. The FWHM calibration factors are offset and slope. The

FWHM calibrations mainly a characteristic of the detector itself (at high voltage). It is also a function of the amplifier and the count rate. The FWHM is done simultaneously with the energy calibration.

C.) **Efficiency Calibration:** The purpose of the efficiency calibration is to establish the relationship between the number of counts detected in a series of peaks in the particular geometry and the number if gammas being emitted from the source for these peak energies. Efficiency calibration is very sensitive to changes in sample shape or in the distance between the detector and the sample. The fact that several different shapes and sizes of samples are dealt with requires that an efficiency calibration be maintains for each geometry (sample type).

Some peaks will always occur in a spectrum no matter what the sample contains. In most cases these peaks result from natural background radiation. This background radiation usually comes from long-lived Thorium, Radium, and Uranium alpha decay chains, as well as the decay of potassium (K)- 40, which exists in normal construction materials and soil. For this reason, background spectra are counted periodically and subtracted from all samples. Background spectra are collected once per week after energy calibrations are accomplished. It is very important that all calibration sources are removed from the room as they may cause an elevated background counts.

Before a batch of samples are counted, a quality control (QC) is performed for the same geometry. QC are performed on all geometry types for all detectors when detectors are idle. This is done to provide enough QC data points so that any trending may be immediately identified. A 2000 second count (approximately 33 minutes) is initiated with the appropriate sample and a calibration check report will automatically be generated. This report flags any results that is outside of the established QC limits. All components of the gamma spectroscopy system are subject to drift, which will affect all of the calibration parameters. Drift may occur over a period of time in response to a change in environmental conditions (temperature and humidity) or a sudden voltage spike, etc.

Samples may be counted only after energy and efficiency calibrations, background counts, and quality control counts have been accomplished and verified to be correct and accurate. When a batch of samples for gamma spectroscopy analysis is received in the counting section, it is logged onto the sample receipt log. For each sample the tracking number (sample number) and sample name (sample type and base or other appropriate identification) along with the stop date (collection date), the sample quantity, sample units, count time, and the appropriate geometry are recorded. The analysis report is automatically reported after each count is completed. This

is a summary of the steps taken to run the samples and receive information about the nuclide activity present within these samples.

<u>Results</u>

The results obtained are based on the concentrations of radium-226, thorium-232, and uranium-238 present in the samples collected. The range of values for each of the selected radionuclides in this study were derived from the "Determination of Concentrations of Selected Radionuclides in Surface Soil in the US" survey made by the Remedial Action Survey and Certification Activities Group of the Health and Safety Research Division at Oak Ridge National Laboratory in 1983. According to the reported range of values for Texas, Radium - 226 is at 0.54 - 1.4 pCi / gm, Thorium - 232 is at 0.40 - 1.1 pCi / gm and Uranium - 238 is at 0.48 - 1.5 pCi / gm. The results are as follows:

	Radium- 226 (pCi / gm)	Thorium-232 (pCi / gm)	Uranium-238 (pCi / gm)
soil # 1	1.73	.871	.593
soil # 2	1.75	.784	.722
soil # 3	1.72	.859	.681
soil # 4	1.32	.999	.446
soil # 5	.61	.625	.166
soil # 6	2.21	.629	not found
soil # 7	2.89	1.59	2.77
soil # 8	.64	.08	.24
soil # 9	.75	.19	.38
soil # 10	1.22	.26	1.2
water # 1	.043	.01	.18
water # 2	.12	.02	.12
water # 3	.25	.02	.20
water # 4	.22	.02	.20

Conclusion

The range of values for radium - 226, thorium - 232, and uranium - 238 were based on the "Determination of Concentrations of Selected Redionuclides in Surface Soil in the US" survey made by the Oak Ridge National Laboratory. All of the results for thorium - 232 and uranium - 238 correspond with the range of values established for the average concetration in Texas. 80% of the radium - 226 results fell within the average range of values for the state of Texas. From these results I can conclude the samples collected from my area contained the expected average of radionuclide activity for the state of Texas.

References

1. Branch Operating Instruction 161- Occupation Environmental Directorate (AFMC) 24 - May - 96

2. " Determination O f Concentrations Of Selected Radionuclides In Surface Soil In The U.S." Health Physics Vol. 45 No. 3 (September), pp. 631- 642, 1983

3. Dyson, N. A. *X - Rays in Atomic and Nuclear Physics - Second Edition* (Cambridge University Press)

4. Erwall, L.G. , Forsberg, H.G. and Ljunggren, K. *Industrial Isotope Techniques* (New York: John Wiley & Sons, Inc.)

5. Hall, Eric J. "Radiation and Life." http://www.uic.com.au/ral.htm (12 June 1996)

6. Lillie, David W. *Our Radiant World* (Amese, Iowa: Iowa State University Press)

7. "Radiation Related Terms." http.//ww.sph.umich.edu/%7Ebbusby/terms.htm#top (12 June 1996).

8. Wheaton, Bruce R. *The Tiger And The Shark: Empirical Roots Of Wave - Particle Dualism* (New York: Cambridge University Press)